

Volume 1 of 3

**Site Assessment
Rhone-Poulenc Facility
Tukwila, Washington**

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Prepared for

Boeing Environmental Affairs
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Prepared by

Landau Associates, Inc.
P.O. Box 1029
Edmonds, WA 98020-9129
(206) 778-0907



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EXECUTIVE SUMMARY

This report presents the results of Landau Associates, Inc. environmental site assessment of the Rhone-Poulenc facility located at 9229 East Marginal Way South in Tukwila, Washington. From 1952 to April 1991, the site was primarily used to produce artificial vanilla (vanillin) from sulfite black liquor, a by-product of the pulp and paper industry. Prior to 1952 the site was used to manufacture glue, paints, resins, and wood preservatives, as an industrial laboratory, and as a prisoner of war camp during the early to mid-1940s.

The site investigation evaluated soil and groundwater quality on the terrestrial portion of the property and sediment and seep quality on the marine portion of the property along the Duwamish Waterway. The property does not include Slip No. 6. Constituent levels of concern were detected at numerous areas onsite. Each of the areas of concern were evaluated as either very likely to require remediation (90-100 percent probability based on Landau Associates' best professional judgment), moderately likely (roughly 40-50 percent), low likelihood (roughly 10-20 percent), or unlikely (0-10 percent).

Two areas of the property, the MW-G5 Plume Area and the Sector B Area, will very likely require remediation. The primary constituent of concern in these areas is toluene which was extensively used to produce vanillin. Toluene is present at high levels in the soil and groundwater in the MW-G5 Plume Area and in the soil in the Sector B Area. Over 2 ft of floating product (toluene) was measured in one well in the MW-G5 Plume Area. The cost to remediate the MW-G5 Plume Area is estimated to range from \$2.6 to \$3.8 million and would probably take between 2 to 5 years to complete. The lower estimate is based on the use of vacuum extraction to treat soil, and groundwater "pump and treat" to treat groundwater. The higher estimate is based on *in situ* bioremediation to treat both soil and groundwater. Both alternatives would encumber site development activities during the remediation effort. These estimates are also based on numerous assumptions including extent of constituents of concern, length of time required to remediate the site, and obtaining a permit to discharge pre-treated water to Metro.

The cost to remediate Sector B soil is estimated to range from \$0.64 to \$6.1 million. The lower estimate is based on the use of vacuum extraction and would likely require at least 2 years. The higher estimate assumes the soil containing toluene is excavated and hauled to an offsite RCRA landfill near Arlington, Oregon for disposal. The excavate and haul alternative

would likely require 3-6 months. The excavate and haul alternative was determined to be impractical for the MW-G5 Plume Area because the area contains toluene in both soil and groundwater.

A third area of concern, referred to as the Black Liquid Plume, is considered to have a moderate likelihood of requiring remediation. The Black Liquid Plume consists of a large area of the site where shallow monitoring wells contain a dark brown to black liquid resembling the black sulfite liquor. The black liquid contains high concentrations of total organic carbon (TOC) and moderate concentrations of chromium. The Black Liquid Plume is considered to have a lower likelihood of requiring remediation than the areas discussed above because the black liquid contains lower levels of hazardous constituents. The cost to remediate this area is estimated to be \$2.4 million assuming the plume is pumped through wells and the water is discharged directly to the sanitary sewer. The estimated cost is highly dependent on receiving authorization from Metro to discharge to the sanitary sewer and on estimated flow rates. Because of expected high flow rates, it is likely that portions of the plume would be remediated at different times to avoid overloading the sanitary sewer. This approach would likely extend the required time for remediation to at least 5 years.

Two other areas of the site were considered to have a low likelihood that remediation would be required. These include groundwater containing copper and chromium in Sector H and soil containing copper in Sector B. The concentrations of these constituents were relatively low and therefore remediation costs were not estimated.

Constituent concentrations in marine sediments include marginal exceedance of some of Ecology's Sediment Management Standards (WAC 173-204) criteria; however, remediation of marine sediment is unlikely to be required. If dredging is required, additional costs will be incurred either to demonstrate sediment suitability for unconfined open-water disposal or to evaluate alternative disposal options.

Although remediation of the Black Liquid Plume and Sector H groundwater may not be required, the presence of elevated levels of TOC and metals in groundwater in these areas may result in additional construction costs during site development because discharge of dewatering water could be restricted. In this case, the water may require onsite treatment and/or discharge to the Metro sewer (if approved by Metro). Because it is not possible to determine dewatering flow rates and pumping durations at this time, an estimate for additional dewatering costs is not provided. However, unless the dewatering pumping rate is very high or the duration very long,

it is unlikely that the cost to address constituents in the dewatering water will be greater than the cost to remediate the groundwater as discussed above.

A summary of the estimated remediation costs is presented below. The estimate includes funding for additional environmental investigations.

COST SUMMARY^(a)

Area	Estimated Likelihood that Remediation Will Be Required	Estimated Costs of Technologies Evaluated	Estimated Time Frame for Remediation (years)
MW-G5 Plume Area	90% - 100%	\$2.6 to \$ 3.8	2 - 5
Sector B Soil	90% - 100%	\$0.64 to \$ 6.1	0.25 - 2
Black Liquid Plume Area	40% - 50%	\$2.4	2 - 5
	Total	\$5.6 to \$12.3	

(a) All costs in millions of dollars.

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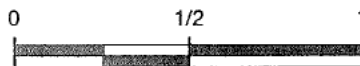
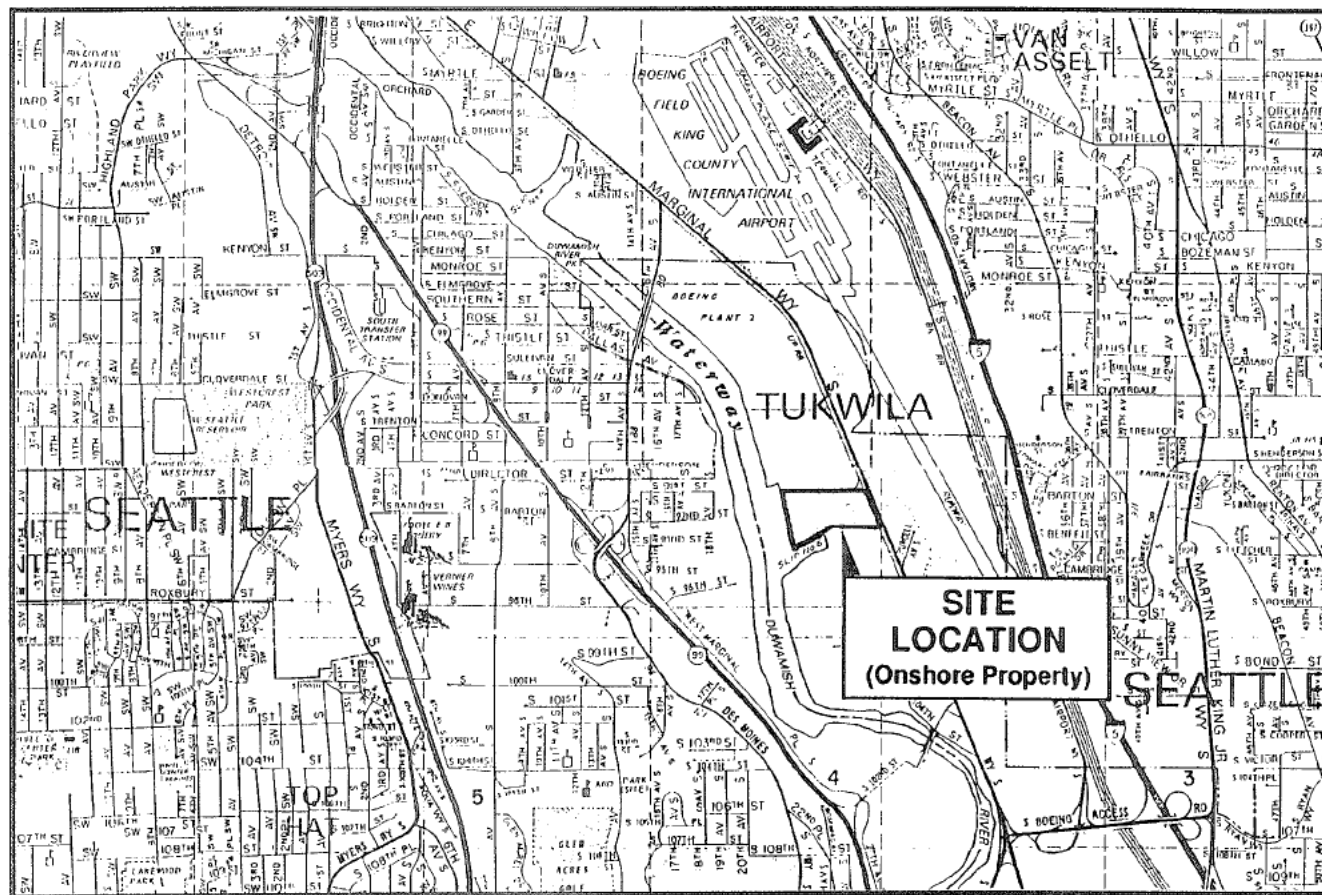
1.0 INTRODUCTION

This report presents the results of Landau Associates, Inc. environmental site assessment of the Rhone-Poulenc facility located at 9229 East Marginal Way South in Tukwila, Washington, as shown on Figures 1-1 and 1-2. The purpose of the site assessment is to characterize the chemical quality of groundwater, soil, and sediment within the property boundaries of the site in order to evaluate the level of environmental damage, if any, that can be attributed to past practices at the site. A secondary purpose is to use the results of this evaluation to estimate potential costs to remediate the site, if remediation is needed. This site assessment does not include an evaluation of asbestos-related issues or demolition and surface debris issues.

An environmental site assessment of the property was accomplished in 1986 by Rhone-Poulenc prior to purchasing the property from Monsanto Corporation in 1986. The results of the 1986 site assessment are presented in Dames & Moore (1986). Some of the information contained in that report is incorporated into this report and is identified by reference to the Dames & Moore report. Monitoring wells installed during the 1986 site assessment were sampled during this site assessment.

An evaluation of the site history and a work plan for the site assessment are presented in the draft Initial Site Evaluation and Proposed Investigation Report (Landau Associates 1991a). Much of the site background information from that report is also presented in this report.

The scope, site history, site description, and site hydrogeology are presented in Sections 2.0, 3.0, 4.0, and 5.0, respectively. Section 6.0 evaluates applicable screening criteria for identifying areas of concern at the site and areas potentially requiring remediation. Section 7.0 presents the major findings of the investigation, compares the chemistry data to the screening criteria developed in Section 6.0, and evaluates whether remedial action is likely in those areas where the screening criteria were exceeded. Section 8.0 evaluates potential remedial actions for those areas where remediation is determined to be likely and provides a cost estimate for the remedial action. Section 9.0 discusses several limitations of the investigation.



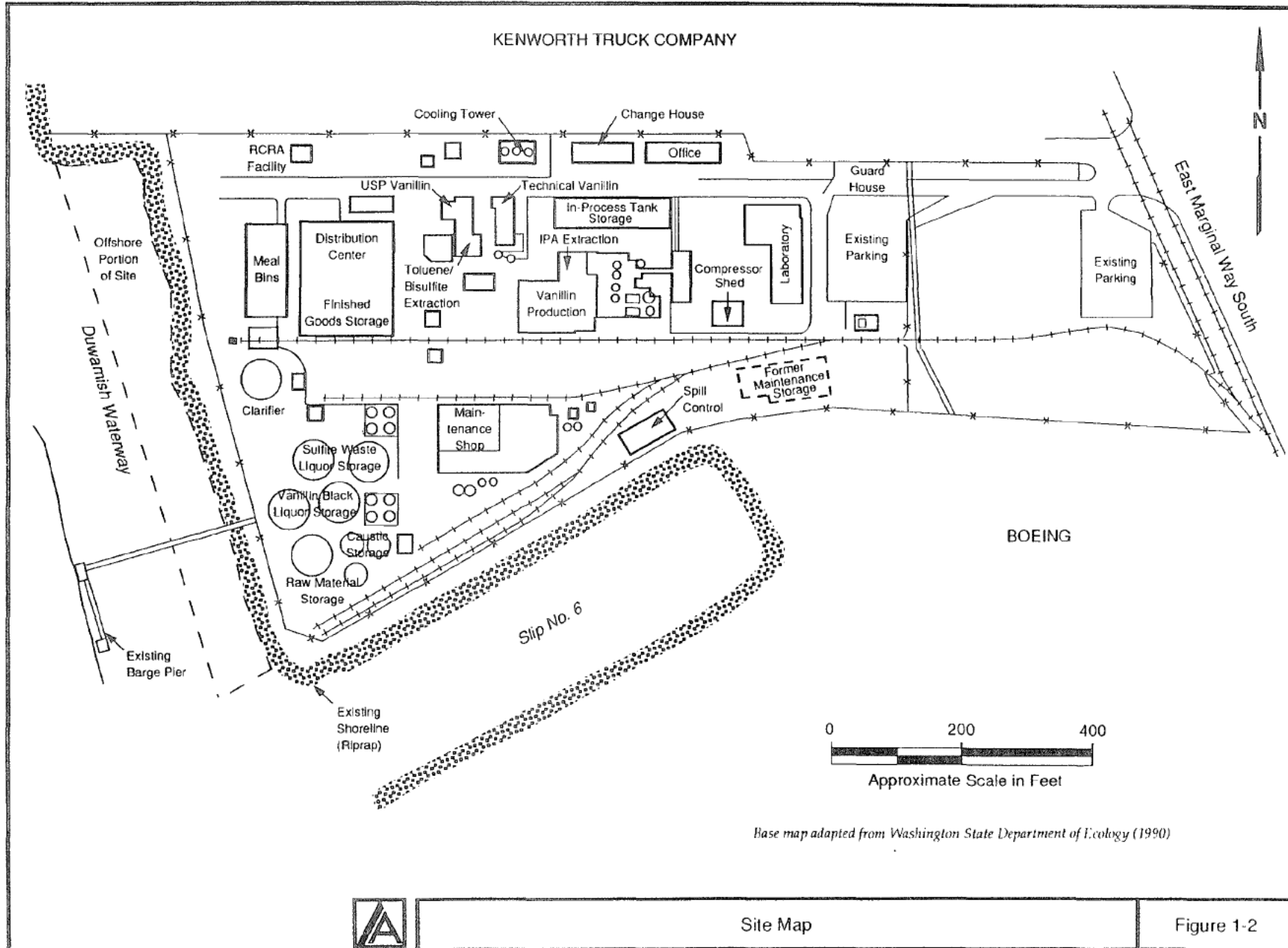
Scale in Miles



Vicinity Map

Figure 1-1

1-3



2.0 SCOPE OF SERVICES

Landau Associates scope of services for this project consisted of the following major elements:

- Preparing an initial site evaluation report which included a site history and evaluation to identify areas of potential environmental concern
- Preparing a site investigation plan (i.e., work plan)
- Drilling and installing 16 (approximately 20 ft) and 2 (approximately 50-ft) monitoring wells with hollow-stem auger drilling equipment, and collecting soil samples at 2.5-5 ft intervals
- Drilling and installing one 100-ft monitoring well with cable tool drilling equipment and collecting soil samples at 10-20 ft intervals
- Drilling 36, 10- to 15-ft soil borings with solid-stem auger drilling equipment and collecting soil samples at 2.5-ft intervals
- Hand augering one 11.5 ft soil boring and collecting soil samples at 2.5 ft intervals
- Coring eight 3- to 5-ft borings in the intertidal area with a vibracorer and collecting continuous soil samples
- Developing the new monitoring wells
- Sampling 30 onsite monitoring wells including 11 existing wells that were installed in 1986
- Sampling three seeps in the intertidal zone
- Surveying the well, boring, and seep locations for elevation
- Measuring the groundwater levels in all onsite monitoring wells on two separate occasions
- Preparing this report.

Exploration locations are shown on Figure 2-1, which is divided into eight sectors to more easily locate individual exploration locations. The sectors generally correspond to areas of the site that have similar operations or uses (i.e., process area=Sector B, liquid storage area=Sector H). The onshore and offshore field procedures used during this investigation are presented in Appendices A and B, respectively. With the exception of grain-size analyses of sediment samples, all sample analyses were contracted by Boeing to an outside laboratory [Analytical Resources, Inc. (ARI) of Seattle, Washington]. A summary of the analyses that were accomplished on soil, groundwater and sediment samples is presented in Tables 2-1, 2-2, and 2-3, respectively.

2-2

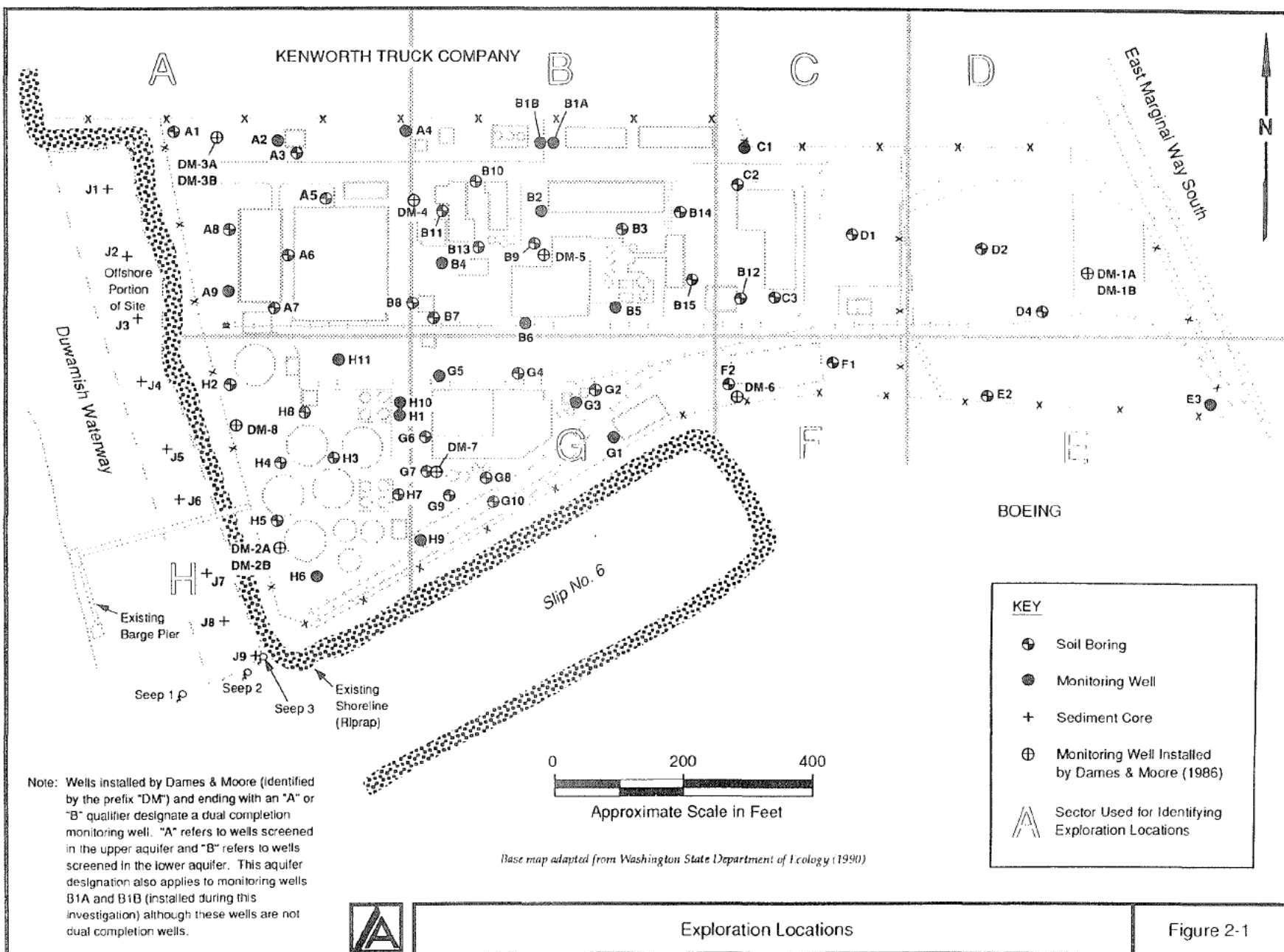


TABLE 2-1
SOIL ANALYSES

Sample Location Identification	Sample Depth (ft below ground surface)	Volatile Organics	Semivolatile Organics	Metals	pH	Pesticides	PCBs	Isopropyl Alcohol
A1	2.5	X	X	X	X	X	X	--
A1	5.0, 12.5	X	X	X	--	--	--	--
A1	7.5	X	X	X	X	--	--	--
A2	2.5, 7.5	X	X	X	X	--	--	--
A2	5.0, 10.0, 15.0	X	X	X	--	--	--	--
A3	2.5, 7.5	X	X	X	X	--	--	--
A3	5.0, 12.5	X	X	X	--	--	--	--
A4	2.5, 7.5	X	X	X	X	--	--	--
A4	5.0, 10.0, 15.0, 20.0	X	X	X	--	--	--	--
A5	2.5, 5.0, 7.5	X	X	X	--	--	--	--
A6	2.5, 5.0, 7.5, 12.5	X	X	X	--	--	--	--
A7	2.5, 5.0, 7.5, 12.5	X	X	X	--	--	--	--
A8	2.5, 5.0, 7.5, 15.0	X	X	X	--	--	--	--
A9	2.5, 5.0, 7.5, 10.0, 15.0	X	X	X	--	--	--	--
B1A	2.5, 5.0, 7.5, 10.0, 15.0	X	X	X	--	--	--	--
B1B	30.0, 50.0, 73.0, 95.0	X	X	X	--	--	--	--
B2	2.5, 7.5	X	X	X	--	--	--	X
B2	5.0, 10.0, 15.0	X	X	X	--	--	--	--
B3	2.5, 7.5	X	X	X	--	--	--	X
B3	5.0, 10.0	X	X	X	--	--	--	--
B4	2.5, 5.0, 7.5, 12.5, 15.0, 30.0, 52.5	X	X	X	--	--	--	--
B5	2.5, 7.5	X	X	--	--	--	--	X
B5	5.0, 10.0, 15.0	X	X	X	--	--	--	--
B6	2.5, 7.5	X	X	X	--	--	--	X
B6	5.0, 10.0, 15.0	X	X	X	--	--	--	--
B7	2.5	X	X	X	--	--	X	X
B7	5.0, 7.5, 10.0	X	X	X	--	--	--	--
B8	2.5, 5.0, 7.5, 10.0	X	X	X	--	--	--	--
B9	2.5, 7.5	X	X	X	--	--	--	X
B9	5.0, 10.0	X	X	X	--	--	--	--
B10	2.5, 5.0, 7.5	X	X	X	--	--	--	--
B11	2.5, 5.0, 7.5	X	X	X	--	--	--	--
B11 (DUP) ^(a)	2.5	X	X	X	--	--	--	--
B12	2.5, 5.0, 7.5, 12.5	X	X	X	--	--	--	--
B13	2.5, 5.0, 7.5, 10.0	X	X	X	--	--	--	--

TABLE 2-1
SOIL ANALYSES

Sample Location Identification	Sample Depth (ft below ground surface)	Volatile Organics	Semivolatile Organics	Metals	pH	Pesticides	PCBs	Isopropyl Alcohol
B14	2.5, 5.0, 7.5, 10.0	X	X	X	--	--	--	--
B15	2.5, 5.0, 7.5, 10.0	X	X	X	--	--	--	--
C1	2.5, 5.0, 7.5, 10.0, 15.0	X	X	X	--	--	--	--
C2	2.5, 5.0, 7.5, 10.0	X	X	X	--	--	--	--
C3	2.5, 5.0, 7.5, 12.5	X	X	X	--	--	--	--
D1	2.5	X	X	X	--	X	--	--
D1	5.0, 7.5, 12.5	X	X	X	--	--	--	--
D2	2.5, 5.0, 7.5, 12.5	X	X	X	--	--	--	--
D4	2.5	X	X	X	--	X	--	--
D4	5.0, 7.5, 10.0	X	X	X	--	--	--	--
E2	2.5, 5.0, 7.5, 10.0	X	X	X	--	--	--	--
E3	2.5, 5.0, 7.5, 10.0, 15.0	X	X	X	--	--	--	--
E3 (DUP) ^(b)	7.5	X	X	--	--	--	--	--
F1	2.5, 5.0, 7.5, 12.5	X	X	X	--	--	--	--
F2	2.5, 4.5, 7.5, 11.5	X	X	X	--	--	--	--
G1	2.5, 7.5	X	X	X	X	--	--	--
G1	5.0, 10.0, 15.0, 20.0	X	X	X	--	--	--	--
G2	2.5, 5.0, 7.5, 11.5	X	X	X	--	--	--	--
G3A	2.5, 7.5, 10.0, 15.0	X	X	X	--	--	--	--
G3A	20.0	X	X	X	X	--	--	--
G4	2.5, 5.0, 7.5, 10.0	X	X	X	--	--	--	--
G5	2.5, 5.0, 7.5, 11.5, 13.0, 20.0	X	X	X	--	--	--	--
G6	2.5, 5.0, 7.5, 13.0	X	X	X	--	--	--	--
G7	2.5, 5.0, 7.5, 12.5	X	X	X	--	--	--	--
G8	2.5, 5.0, 7.5, 11.5	X	X	X	--	--	--	--
G8 (DUP) ^(c)	2.5, 5.0, 7.5, 11.5	X	X	X	--	--	--	--
G9	2.5, 5.0, 7.5, 11.5	X	X	X	--	--	--	--
G10	2.5, 4.8, 7.5, 10.0	X	X	X	--	--	--	--
H1	2.5, 5.0, 7.5, 10.0, 12.5, 20.0, 35.0, 40.0, 50.0, 54.0	X	X	X	--	--	--	--
H1 (DUP) ^(d)	10.0							
H2	2.5	X	X	X	--	X	X	--
H2	5.0, 7.5	X	X	X	--	--	--	--
H3	2.5, 5.0, 7.5, 10.0	X	X	X	--	--	--	--

TABLE 2-1
SOIL ANALYSES

Sample Location Identification	Sample Depth (ft below ground surface)	Volatile Organics	Semivolatile Organics	Metals	pH	Pesticides	PCBs	Isopropyl Alcohol
H4	2.5, 5.0, 7.5	X	X	X	--	--	--	--
H4 (DUP) ^(e)	7.5, 10.0	X	X	X	--	--	--	--
H5	5.0, 11.5	X	X	X	--	--	--	--
H5	2.5, 7.5	X	X	X	X	--	--	--
H6	5.0, 11.5, 15.0	X	X	X	--	--	--	--
H6	2.5, 7.5	X	X	X	X	--	--	--
H7	2.5, 5.0, 7.5, 11.5	X	X	X	--	--	--	--
H8	2.5, 5.0, 7.5, 11.5	X	X	X	--	--	--	--
H9	2.5, 7.5, 10.0, 15.0, 20.0	X	X	X	--	--	--	--
H9	5.0	X	X	X	X	--	--	--
H11	2.5, 5.0, 7.5, 10.0, 15.0	X	X	X	--	--	--	--
H11 (DUP) ^(f)	10.0	X	X	X	--	--	--	--

(a) Sample identified as PV-BN-B11-25.0 in laboratory data sheets (Appendix J, Volumes 2 and 3).

(b) Sample identified as PV-MW-E3-75.0 in laboratory data sheets (Appendix J).

(c) Samples identified as PV-BN-G8-25.0, PV-BN-G8-50.0, PV-BN-G8-75.0, and PV-BN-G8-115.0 in laboratory data sheets (Appendix J).

(d) Sample identified as PV-MW-H1-100.0 in laboratory data sheets (Appendix J).

(e) Samples identified as PV-BN-H4-75.0 and PV-BN-H4-100.0 in laboratory data sheets (Appendix J).

(f) Sample identified as PV-MW-H11-100.0 in laboratory data sheets (Appendix J).

X Indicates analyses were accomplished on the sample.

-- Indicates analyses were not accomplished on the sample.

TABLE 2-2
GROUNDWATER AND SEEP ANALYSES

Sample Location Identification	Volatile Organics	Polynuclear Aromatic Hydrocarbons	Metals	Isopropyl Alcohol	Formaldehyde	Total Organic Carbon
A2	X	X	X	--	--	X
A4	X	X	X	--	--	X
A9	X	X	X	--	X	X
B1A	X	X	X	--	--	X
B1B	X	X	X	--	X	X
B2	X	X	X	--	--	X
B4	X	X	X	--	--	X
B5	X	X	X	--	--	X
B6	X	X	X	--	--	X
C1	X	X	X	--	--	X
E3	X	X	X	--	--	X
G1	X	X	X	--	--	X
G3	X	X	X	--	--	X
G5	X	X	X	--	--	X
H1	X	X	X	--	--	X
H6	X	X	X	--	--	X
H9	X	X	X	--	--	X
H10	X	X	X	--	--	X
H10 (DUP) ^(a)	X	X	X	--	--	X
H11	X	X	X	--	--	X
DM1A	X	X	X	--	--	--
DM1B	X	X	X	--	X	--
DM2A	X	X	X	--	--	--
DM2A (DUP) ^(b)	X	X	X	--	X	--
DM2B	X	X	X	--	--	--
DM3A	X	X	X	--	X	--
DM3B	X	X	X	X	--	--
DM4	X	X	X	--	X	--
DM5	X	X	X	--	--	--
DM6	X	X	X	--	--	--
DM7	X	X	X	--	--	--
DM8	X	X	X	--	--	--
SEEP #1	X	X	X	--	X	--
SEEP #2	X	X	X	--	X	X
SEEP #3	X	X	X	--	X	X

(a) Sample identified as MW-H100 in laboratory data sheets (Appendix J, Volumes 2 and 3).

(b) Sample identified as DM102A in laboratory data sheets (Appendix J, Volumes 2 and 3).

X Indicates that analyses were accomplished on the sample.

-- Indicates that analyses were not accomplished on the sample.

TABLE 2-3
SEDIMENT ANALYSES

Sample Location Identification	Sample Depth (ft below ground surface)	Volatile Organics	Semivolatile Organics	PCBs	Total Metals	Total Organic Carbon	Total Solids	Particle Size
J1	0.0-0.5, 2.3-3.8	X	X	X	X	X	X	X
J2	0.0-0.5, 2.5-3.5	X	X	X	X	X	X	X
J3	0.0-0.5, 0.5-1.5	X	X	X	X	X	X	X
J3 (DUP)	10.0	X	X	X	X	X	X	X
J4	0.0-0.5, 1.5-2.5	X	X	X	X	X	X	X
J5	0.0-0.5	X	X	X	X	X	X	X
J6	0.0-0.5, 2.4-3.4	X	X	X	X	X	X	X
J7	0.0-0.5, 2.5-3.5	X	X	X	X	X	X	X
J9	0.0-0.5, 2.5-3.5	X	X	X	X	X	X	X

X Indicates that analyses were accomplished on the sample.

3.0 SITE HISTORY

3.1 SITE USES

Before the turn of the century, the site was used as agricultural pasture land. A meander of the Duwamish River flowed past the southern boundary of the site. After the turn of the century, agricultural use of the site was supplemented by recreational use as a destination getaway for Seattleites. On the 1911 Kroll Map Co. and 1917 U.S. Army Corps of Engineers maps of the site area, the site is labeled as a "Fairground" and "The Meadows", as shown on Figure 3-1. In about 1918, the U.S. Army Corps of Engineers straightened much of the meandering Duwamish River through dredging and filling. Dredged material was used to fill the river channel and the area between the river meanders. The original course of the Duwamish River included Slip No. 6, as shown on Figure 3-2. This portion of the river was left unfilled to access the new waterway. During this period, the site was apparently in private ownership, with J.F. McElroy listed as the site owner. As shown on the 1928 Kroll map (Figure 3-2) and a 1936 aerial photograph, the site continued to be used either as agricultural or undeveloped grassland, with a line of trees located along the southern boundary. The undeveloped nature of the site is corroborated by U.S. Army Corps of Engineers dredging maps from 1933 to 1942, which identify industrial activity north and south of the site, but nothing onsite.

The first known commercial use of the site began in the late 1930s when an industrial laboratory was established on the site by I.F. Laucks Company. Although an exact date of occupancy is not available, the company's 1948 annual report notes that in the 1930s a pilot plant was built to formulate glue for use in plywood manufacturing from Manchurian soybean cake. In addition, the company was involved in the manufacturing of paints, resins, and wood preservatives. During the early to mid-1940s, concurrent with the laboratory, the site was used as a prisoner of war (POW) camp for Italian soldiers. A 1946 aerial photograph shows 20 Quonset huts on the southwest corner of the site and another 38 barracks on the eastern half of the site (which included part of the present Kenworth Motor Truck Company property). In 1949, Monsanto Chemical Company merged with I.F. Laucks Company, took over its onsite facility, and continued manufacturing paints, resins, wood preservatives, and glue. At the same time, the company investigated the feasibility of producing vanillin. As indicated on the 1949 Sanborn fire insurance map (see Figure 3-3), the facility consisted of the following structures and features:

- Wood preservatives and sealer warehouse (including two dry kilns)

- Soybean milling and glue manufacturing plant
- Switch house
- Steel drum storage area
- Transfer yard
- 50,000-gallon water tower
- Six soybean meal bins
- Soybean meal unloading area
- Four phenol oil tanks surrounded by 3-ft concrete walls
- Twelve various oil and chemical tanks surrounded by 3-ft concrete walls.

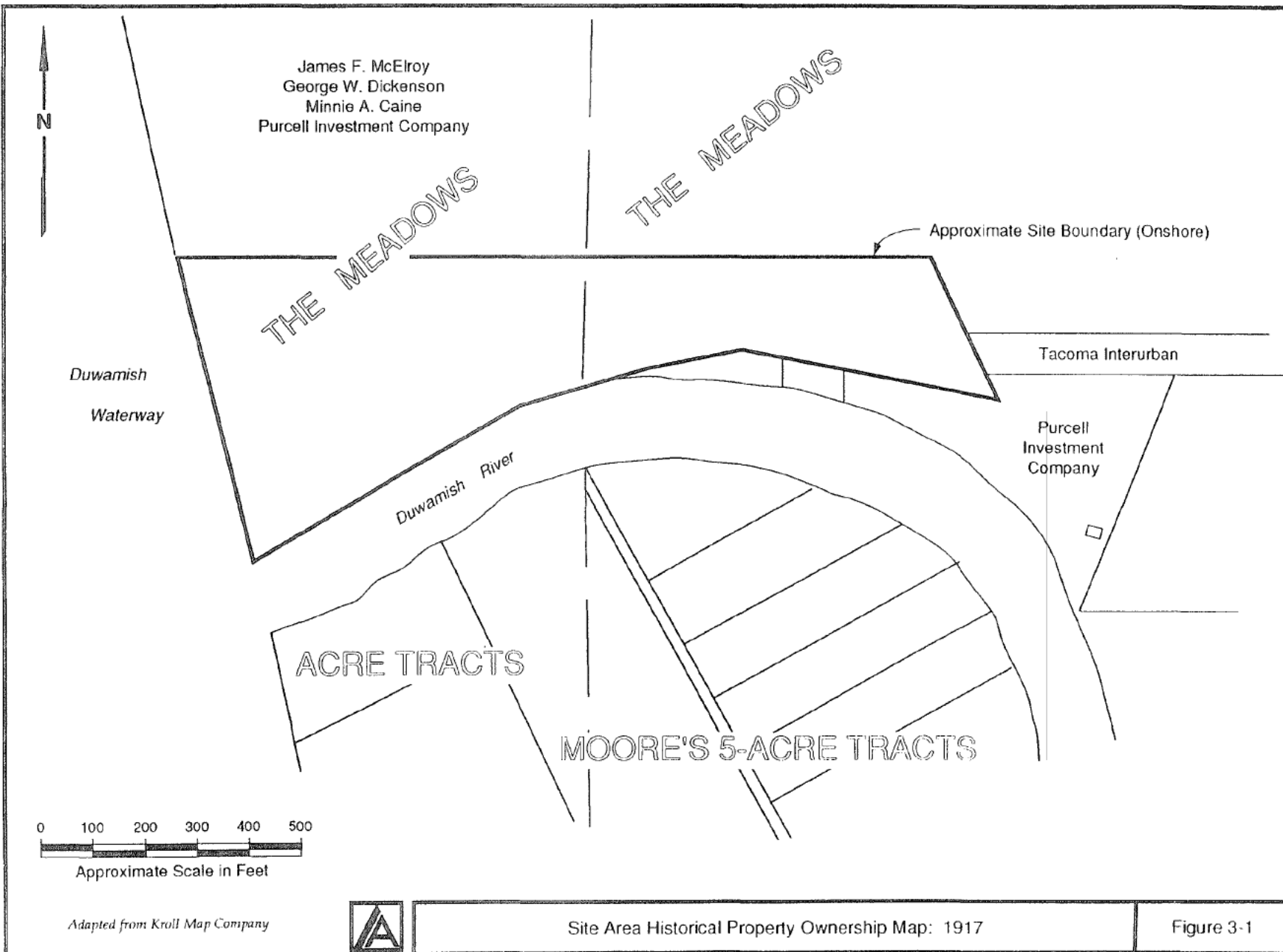
Actual vanillin production began in June 1952 and continued through early 1991. In 1965, Monsanto sold the northern undeveloped portion of its property to the Kenworth Motor Truck Company, as shown on Figure 3-4. Apparently, that part of the site was used to dispose of approximately 200,000 tons of sulfite waste between about 1950 and 1965 (GeoEngineers 1987). Rhone-Poulenc purchased the remaining portion of the property from Monsanto in 1986. Rhone-Poulenc continued to produce vanillin at the site until April 1991 when the plant was permanently shut down.

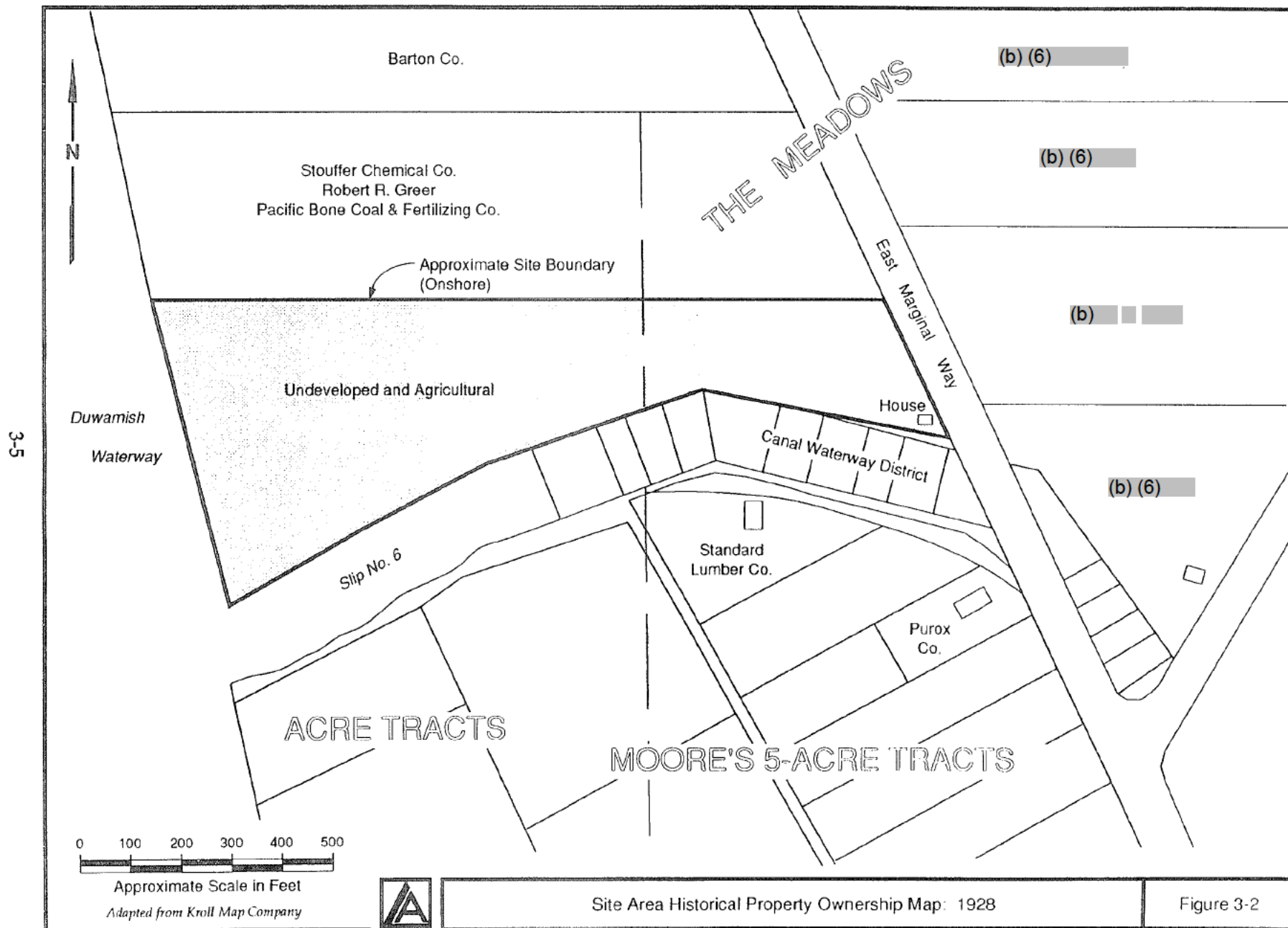
3.2 ADJACENT SITE USES

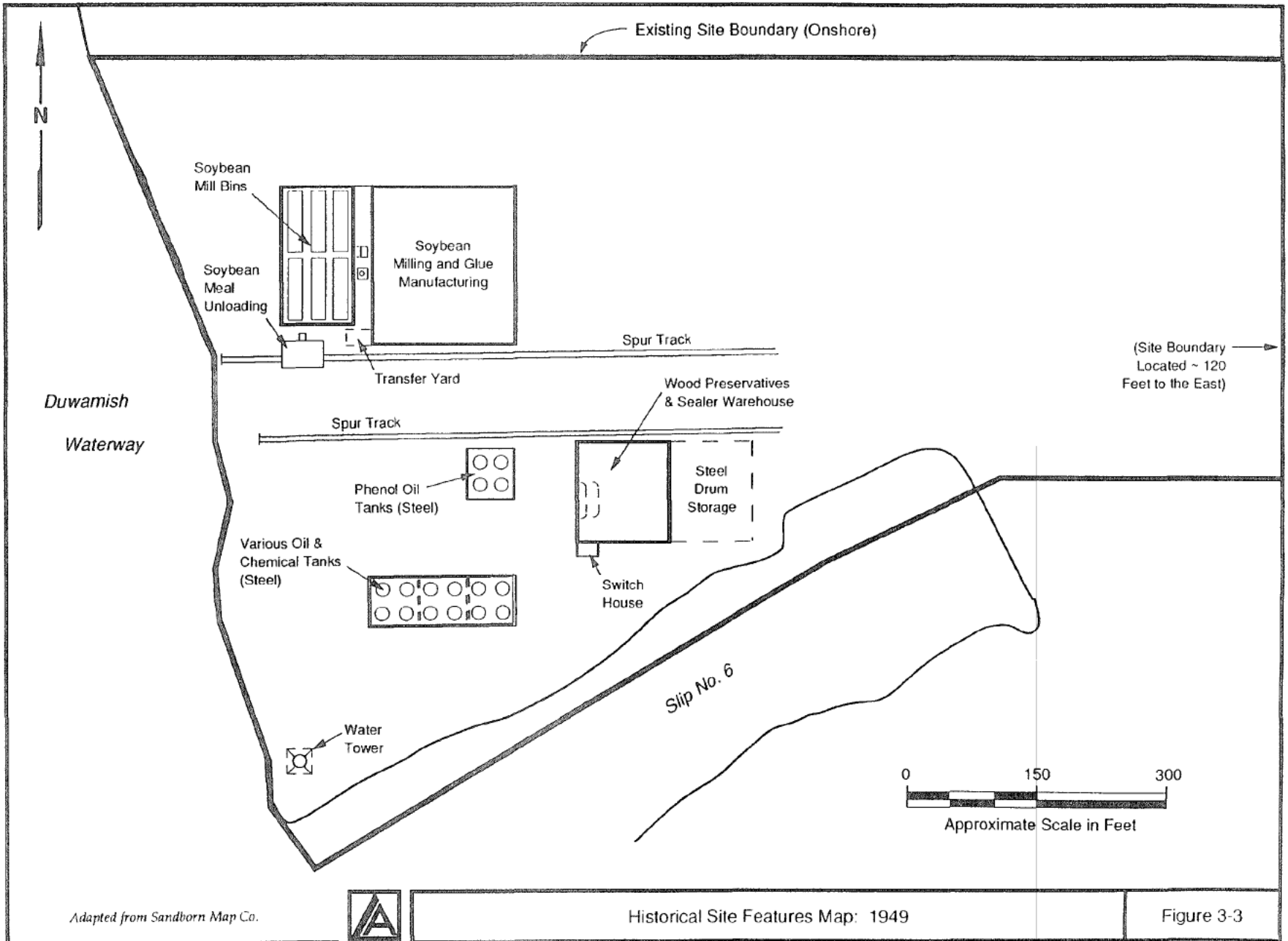
The area surrounding the site developed in much the same way as the site, with mostly agricultural uses occurring south, north, and east of the site until after the Duwamish River was straightened and new slips were established south and north of the site. All surrounding lands were used for agricultural purposes before the turn of the century. The first substantial use of adjacent properties occurred south of the site with the establishment of the Standard Lumber Company in about 1920 which operated at this location until the early 1940s. During the 1940s and 1950s, several structures were built and subsequently demolished on the property to the south. Other known businesses on the property to the south include Pommerelle Wine Company in the mid-1940s, and NAIWCO Wine & Fruit Juice Company in the 1960s and 1970s. Between 1974 and 1977, Terminal 128 was developed on the property to the south for the Port of Seattle. The Boeing Company acquired the Terminal 128 property from the Port of Seattle in 1986.

The first known development north of the site was a small brewery, shown on the 1897 U.S. Army Corps of Engineers map, which was situated off the northeast corner of the present-day Kenworth Motor Truck property. Industrial use of the property north of the site began in the 1920s with the establishment of the Stauffer Chemical Company, whose products and processes are unknown at this time. From the early 1930s to 1952, the Fisher Body Company occupied the site. However, during World War II, Boeing used the plant for production of tanks and heavy military equipment. In 1953, Kenworth Motor Truck Company acquired the site and has operated it to the present.

The area east of the site was first developed as an agricultural area before the turn of the century (the 1897 U.S. Army Corps of Engineers map identifies market gardens, orchards and pasture land in the area). Then it developed into a recreational destination spot shortly before World War I. The 1911 topographic map shows the area occupied by a railroad, which, on the 1920 city atlas, is identified as the Tacoma Interurban. With the extension and expansion of Boeing Field in the 1930s and 1940s, the area became more commercial in nature with the growth of businesses serving airport and travelers' needs; activities continuing to the present.



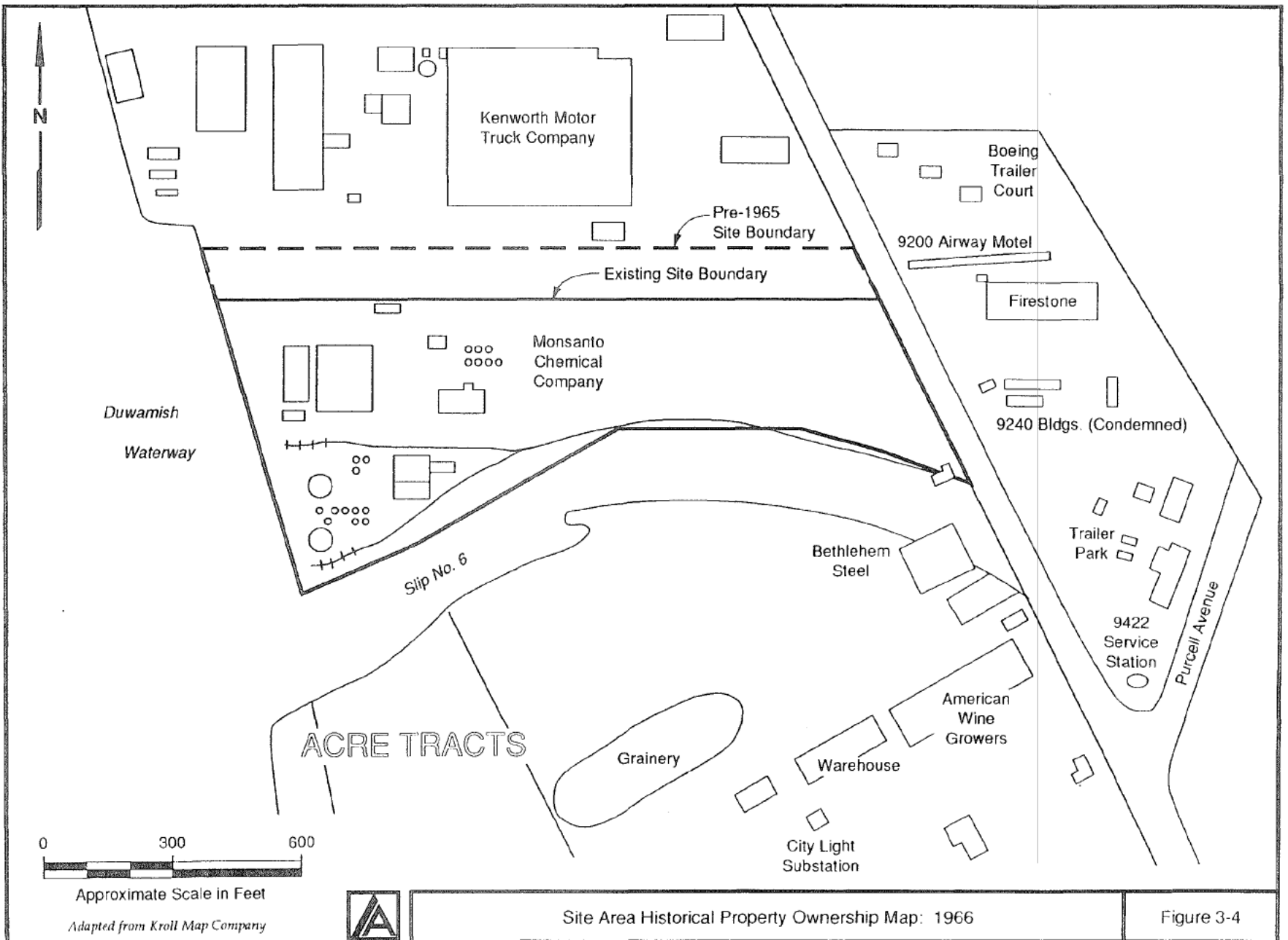




3-6

3-7

Monsanto Company 104(e) Response



4.0 SITE DESCRIPTION

The Rhone-Poulenc facility was most recently used for the production of artificial vanilla, or vanillin. A description of the site history is presented in Section 3.0. The site is bounded by Kenworth Truck Manufacturing Company on the north, the Duwamish Waterway to the west, East Marginal Way South to the east, and Duwamish Waterway Slip No. 6 and The Boeing Company (Boeing) to the south. The onshore portion of the site is approximately 19.5 acres with an additional 2 acres of land offshore. The Rhone-Poulenc property and surrounding area are relatively flat and are zoned industrial. The western two-thirds of the property is occupied by buildings and storage tanks used during the production of vanillin. The eastern third of the property is open and includes areas for parking and storage. A barge pier extends off-property into the Duwamish Waterway on the southwest portion of the property. The plant terminated vanillin production in April 1991.

The remainder of this section discusses the process and raw materials used to produce vanillin and areas of potential environmental concern on the site.

4.1 VANILLIN PROCESS DESCRIPTION

From 1952 to April 1991, the onsite facilities were used to produce vanillin, an artificial vanilla flavoring (vanillin is also used in perfumes and pharmaceuticals). The exact process used to produce vanillin is proprietary; however, a general understanding of the process was developed based on review of agency and Rhone-Poulenc files. A general description of the process based on our current understanding is presented below.

Vanillin is produced synthetically from lignosulfonates (lignin) which is a component in the spent sulfite liquors from sulfite pulp mills. The lignin was obtained from the Georgia Pacific facility in Bellingham, Washington, and was shipped to Rhone-Poulenc by barge. The process of recovery of vanillin from lignin involves the hydrolysis of coniferin, which is a glucoside found in the sapwood of fir trees (and therefore in pulp waste), to yield glucose and coniferyl alcohol, which is subsequently oxidized to vanillin. The other major raw products used in production of vanillin are caustic (sodium hydroxide, lime, or soda ash), which was also received by barge, and copper sulfate, isopropyl alcohol (IPA), and toluene, which were received by truck or rail car. These materials were stored in the southwest corner of the site.

A flowchart for vanillin production at the Rhone-Poulenc facility is illustrated on Figure 4-1. The lignin was pumped to the 13 batch reactors located in the Autoclave Building

(located on the east side of the building labeled Vanillin Production on Figure 4-2). Several of the batch reactors extend east of this building. In the batch process, the lignin, caustic, copper sulfate, and water are mixed together. Air under high pressure is injected to assist and control the reaction, which is mildly exothermic. The batch process takes approximately 3 hours, after which the liquid mixture is pumped to flash tanks where steam and gases are vented to the atmosphere. At this point, the liquid has 1 percent vanillin content. The flash tanks were located adjacent to the Autoclave Building.

From the flash tanks, the liquid was pumped to the process area (labeled Vanillin Production on Figure 4-2) where all remaining processes occurred. The product was first subject to liquid-to-liquid extraction by the introduction of isopropyl alcohol into four extraction towers. This isopropyl alcohol-rich product was then processed in strippers to remove the alcohol for reuse. The product was then sent through a toluene extraction process which has three units. Toluene was stored in the tanks near MW-H10 and was pumped to the process area via an underground line. Sulfuric acid (a 93 percent solution) was added to the product at this point to reduce the pH and to cause the vanillin to attach to the toluene. The product is a 4 percent vanillin solution at this point. The product was then pumped through a Raffinate stripper (clarifier) for removal of the Vanillin Black Liquor (VBL) and copper. The VBL is a by-product material which was sold to pulp mills in the area. A slurry (Vanillin Black Liquor Solids or VBLS) was also derived from the clarifying process. This slurry was filtered to remove the liquid. It is believed that the filtered slurry was sold to a cement plant on an "as-needed" basis, and any slurry not sold was further dried to produce Vanillin Black Liquor Cake (VBLC). This material was trucked to a landfill for disposal.

After passing through the Raffinate stripper, the clarified product, which was toluene rich at this point in the process, was pumped through three hot water extraction wash towers to remove further solids, sodium, and sulfuric acid. The product was then pumped into a flash tank to remove the toluene. At this point, the process was under a vacuum. This negative pressure reduced the boiling point of the liquid product. As the product exited the toluene flash tank, it was a molten material at 80°C and contained 70 percent vanillin (toluene stripped crude or TSC). The product was then subject to a further distillation process which increased the vanillin content to 85 percent. Vanillin Still Bottoms (VSB) were a waste by-product of this distillation process. After distillation, the product was returned to a toluene rich solution and was heated then cooled, which caused the vanillin to crystalize in the three crystallizer units. The product was then sent through a centrifuge for removal of the toluene liquid. The

crystallized product was removed from the centrifuge and dried in a Rotacone dryer which was heated by hot water. The dried product was then drummed as a technical grade product.

If the crystallized, dried product was to be food grade, the product was redissolved in water and alcohol under a vacuum, then recrystallized by cooling in two crystallizers. The product was again centrifuged and the crystallized product was dried in a large Rotacone dryer then packaged in drums. The finished, drummed product is stored in the warehouse building onsite. Rejected product was reinjected into the process for reworking.

4.2 AREAS OF POTENTIAL ENVIRONMENTAL CONCERN

Based on the review of historical data and agency files, areas of potential environmental concern were identified during the initial site evaluation. These areas are locations or facilities where potentially hazardous substances are known to have been or may potentially have been handled. The selection of exploration locations was largely based on providing information on these areas. The areas of concern are identified on Figure 4-2 by location number. The following text provides a brief discussion of each of these locations.

Location 1: Groundwater contamination originating from properties north and east of the Rhone-Poulenc facility may potentially flow through the site toward the Duwamish Waterway and Slip No. 6.

Location 2: The 1946 air photo shows the area immediately north of the site to be a disposal location most likely used by POW encampment.

Location 3: This area was used as a RCRA storage facility by Rhone-Poulenc and Monsanto. The drum storage area was constructed in 1980, and materials stored there included strainer solids (which consist primarily of copper, calcium, and sodium salts), methylene chloride, waste solvents, waste oil, and vanillin still bottoms (which consists primarily of high molecular weight phenolics).

Location 4: Agency file information indicates the area to the west of the cooling tower was used as a materials handling and disposal area.

Location 5: Based on the air photos, the area west of the soybean meal bins appears to have been used for general storage since before 1969.

Location 6: The distribution center and finished goods storage area was formerly used to manufacture glue. The center section of the building, which is multistoried, was the former location of process reactors. The types of glues formerly manufactured onsite include the following: casin glues, blood glues, soybean glues, tapioca flour glues, cresilic resins, urea-

resorcinol formaldehyde resins, melamine formaldehyde resins, resorcinol formaldehyde resins, and melamine-urea formaldehyde resins. Pentachlorophenol, carbon tetrachloride, carbon disulfide, pine oil, and mineral spirits were also present in this area during glue manufacturing.

Location 7: This is the primary area used for the production of vanillin, and includes the process area, the autoclave building, and the control building. The autoclave building houses a portion of the batch reactors where the vanillin production process begins with the mixing of raw materials. The reactors are located in the center of the building in an 8-ft deep by 15-ft wide concrete trench. Materials used in this area include lignin, caustic, and copper sulfate. The southeast corner of the autoclave building contains two gas and oil-fired boilers. Three aboveground tanks containing #2 fuel oil and one containing gasoline were also located in this area. An aboveground tank containing white mineral oil, probably used when the facility manufactured glue, was also located in this area.

The control building is located west of the autoclave building and south of the process area. No chemical processes occurred in this area. The process area is located northwest of the Autoclave building and is multi-storied. The process area is where the product is subject to extraction and recovery using toluene and isopropyl alcohol. A high concentration solution of sulfuric acid was also used in this area to enhance toluene extraction. The process area also contained the toluene bisulfate extraction process, which is where the toluene mother liquor which came off the centrifuged product was subject to bisulfate extraction prior to reintroduction into the process.

The northwest corner of the process area contains a small enclosure where the crystalline vanillin product emerged from one of two dryers directly into drums. This area also contained a used mineral oil tank. This tank may have contained mineral oil which is distilled from vanillin during production.

Location 8: This is the location of the compressor shed. Compressor oils used in the past may have contained PCBs or phthalates.

Location 9: This is the location of the existing chemical laboratory. Flammable solvents were used in the laboratory for testing purposes and were handled in 1 gallon or less containers. Two flammable storage cabinets were located on the exterior of the south wall of the laboratory building. The area immediately to the west of this building appeared as a general storage area in the 1970 air photo. The area to the south of the laboratory showed aboveground tanks in the 1970 air photo.

Location 10: There are two general parking areas onsite. The eastern parking area has also been used for parking tractor trailers.

Location 11: This is an unpaved portion of the property used for parking vehicles and for general storage since 1965. This is also the general location of the former POW encampment.

Location 12: This is the primary process storage area onsite. Four tanks containing di-octylphthalate, which was not used in processes onsite, were also located in this area. Rhone-Poulenc serves as a distributor of di-octylphthalate. Tanks have been present at this location since the 1940s. Materials shipped to or from the property via the existing barge pier (Location 19) were stored in this location. Raw materials used in the vanillin process, such as pulp (sulfite) waste liquor and caustics, were stored here. Review of records indicate a number of spill incidents in this area which released chemicals. Of particular note is a 1986 occurrence, when an accidental release from an underground caustic line from one of the storage tanks occurred approximately 50 ft from Slip No. 6. The Washington State Department of Ecology (Ecology) decided that the material was trapped in the soil and not amenable to recovery. Several other spills in this area are on record with the agencies.

Location 12 also contains the clarifier, where the vanillin black liquor was separated from the product prior to hot water extraction. The vanillin black liquor was stored in an aboveground tank in this area prior to its shipment to paper mills. Vanillin black liquor solids were produced as a by-product during the hot water extraction of the process. This by-product material was first pumped into a containment reservoir, where the fluid portion was pumped into two holding tanks. The remaining material was brought to the filter building which is also in Location 12, located southeast of the clarifier. This building housed a Larox press filter, which took the vanillin black liquor solid (sludge) and pressed the liquid out. The dry vanillin black liquor cake was placed in a dumpster in this building until it was shipped out for disposal. It is possible that materials delivered by train and truck were also stored here.

Location 13: This is the location of the existing maintenance shop and the former wood preservatives warehouse and steel drum storage area. Storage tanks have been located outside the building since the 1950s.

Location 14: Located here is a containment structure used to prevent spillage of process materials into Slip No. 6.

Location 15: This is the location of the former maintenance storage building. Storage tanks were located to the west of this building in the 1970 air photo.

Location 16: Railroad lines used for transferring materials to and from the facility.

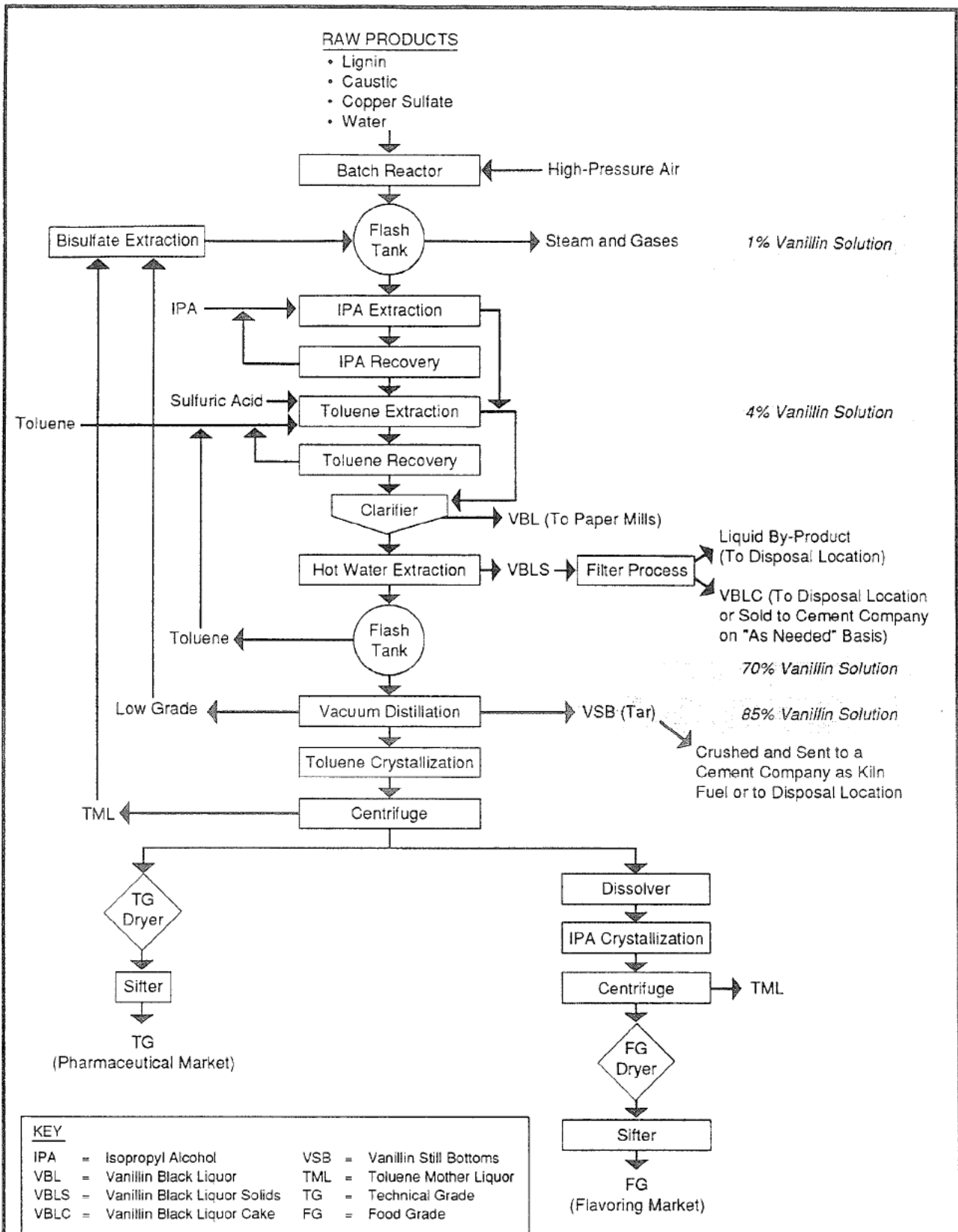
Location 17: Wooded area up to the late 1980s. This area formed the bank of the former Duwamish River which transected the southern portion of the property. The nature of the material used to fill this part of the river channel is unknown.

Location 18: These are locations of former or existing discharge pipes to the Duwamish Waterway and Slip No. 6. Several spills are on record in this area. Of note are two spills which occurred in 1978; the first occurred when a bad coupling on a lignin rail car caused material to be sprayed along the riprap of Slip No. 6; in the second 1978 accident, sulfite waste liquor was spilled into Slip No. 6.

Location 19: This is the existing barge pier used to transfer materials to and from the property.

Location 20: This was the barge pier prior to the 1970s.

In addition to these areas, several areas of concern were identified during the 1986 site assessment. These areas are summarized on Figure 4-3.

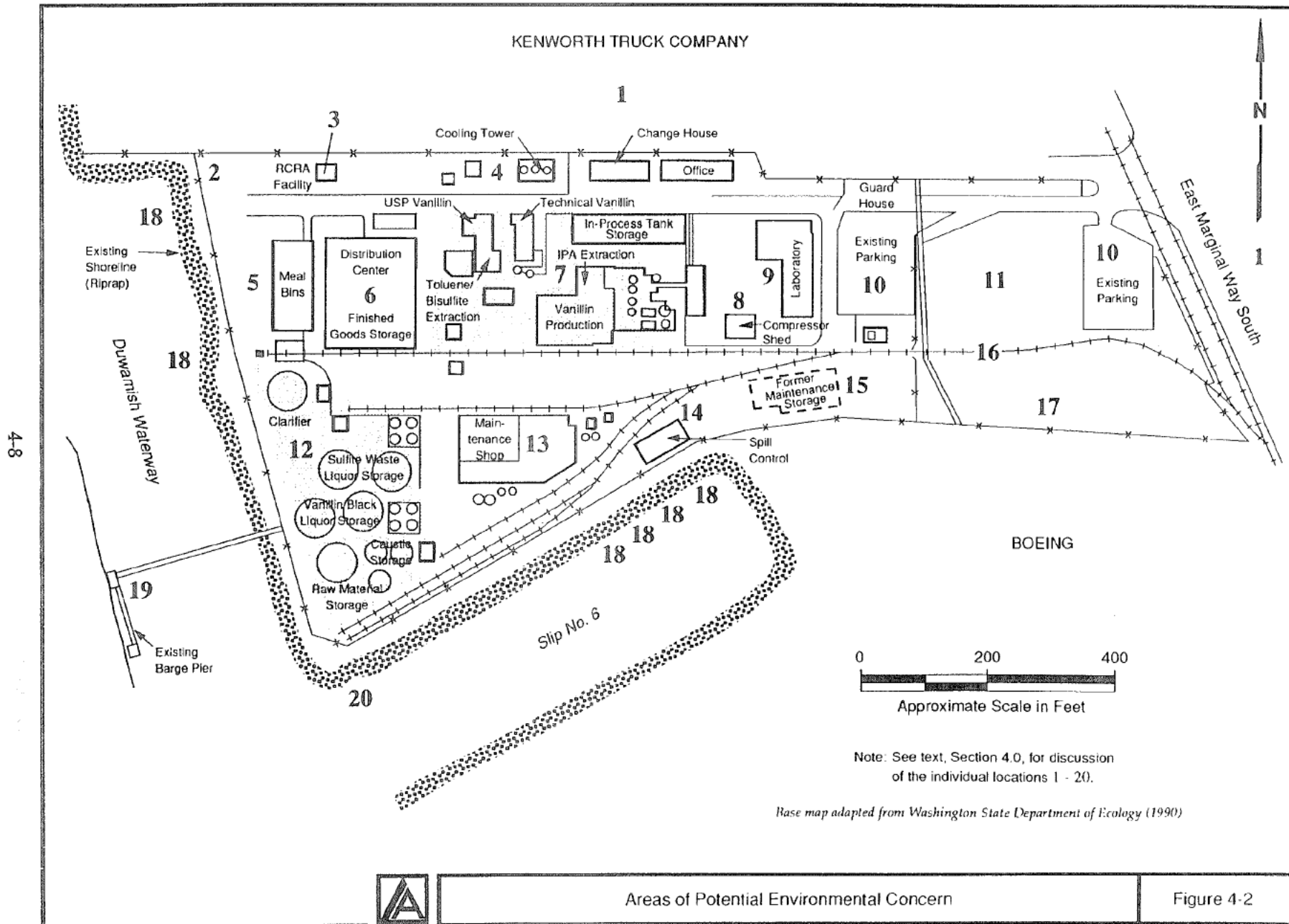


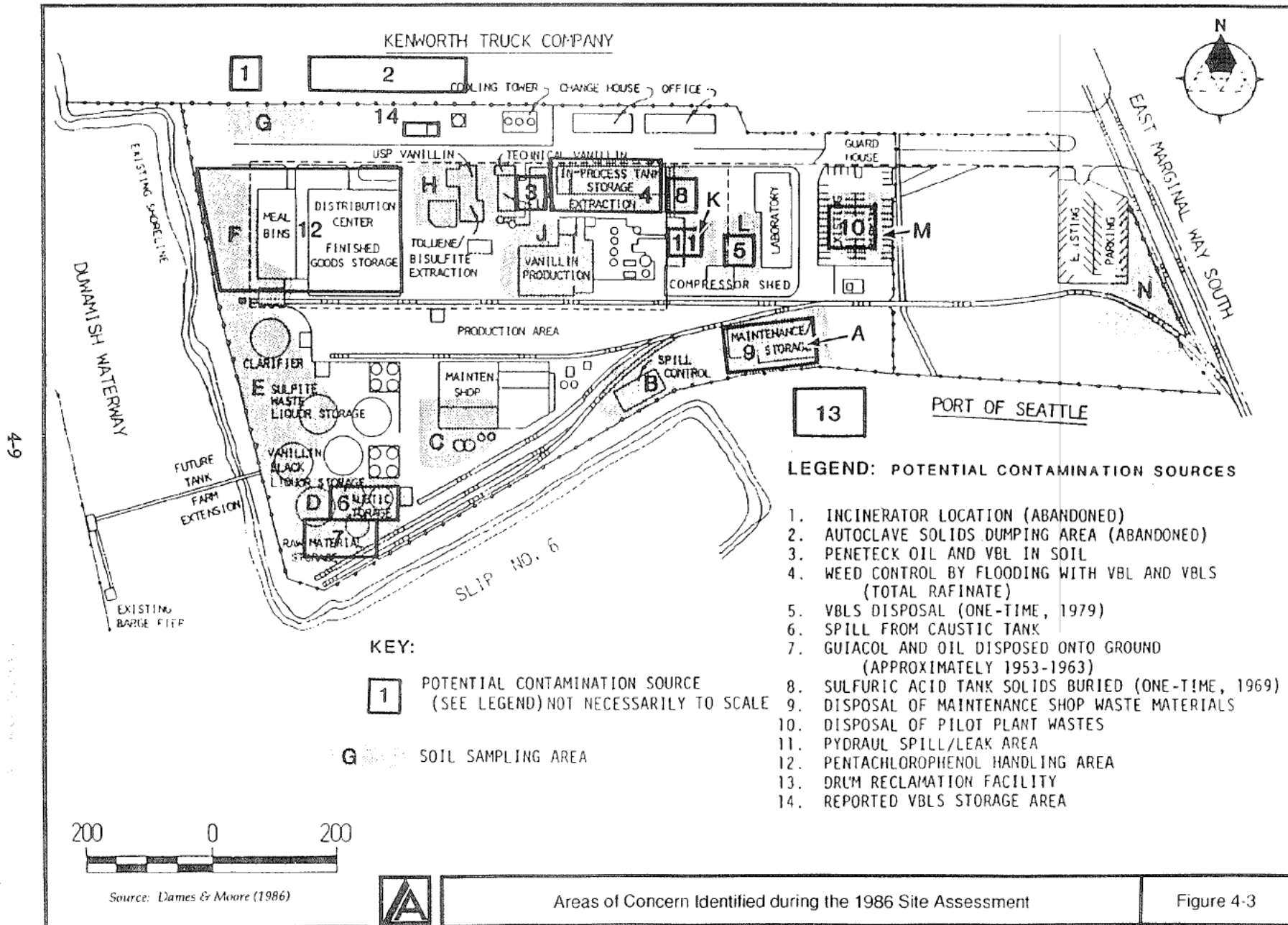
25-63.40 Boiling/Project V/Site Assessment Report 9/91



Vanillin Production Flow Chart

Figure 4-1





5.0 SITE HYDROGEOLOGY

5.1 GEOLOGY

The Rhone-Poulenc property is located on what was historically the floodplain of the meandering Duwamish River. This section of the Duwamish River was straightened by the U.S. Army Corps of Engineers in 1917 and 1918 by dredging and hydraulically filling the floodplain and partially filling the river channel with the dredged sediments. The straightened portion of the river is known as the Duwamish Waterway.

There are three primary near-surface (i.e., less than 100 ft) soil units encountered throughout this portion of the Duwamish River Valley. These units include fill deposits associated with straightening the Duwamish River and more recent fill; alluvial sand and silt deposits derived from the Duwamish River; and gravel, sand, silt, and clay deposits of marine origin. Each of these units were encountered during this investigation. Three geologic cross sections through the site were constructed based on information collected during this investigation and by Dames & Moore (1986). The cross section locations are shown on Figure 5-1, cross sections are shown on Figures 5-2, 5-3, and 5-4. Boring logs of the borings drilled during this investigation are presented in Appendix C (onshore boring logs) and Appendix D (offshore sediment core logs).

The fill deposits at the site consist mainly of fine to medium sand and silty sand. Much of this material was placed hydraulically when the Duwamish River was straightened. Some select fill was placed within specific construction areas. Fill generally includes the upper 5-10 ft of material throughout the site; however, because of the similarity between the hydraulically placed fill and the underlying alluvial deposits, determination of the contact between these deposits is sometimes difficult.

The alluvial sand and silt deposited by the Duwamish River underlies the fill and for the purpose of this study is distinguished into two subunits. Immediately underlying the fill is a zone of dark grey to brown fine to medium sand, and silty fine sand with discontinuous lenses of silt and sandy silt. This subunit extends to a depth of approximately 30-50 ft below ground surface and defines the upper aquifer. As shown in the cross sections, this subunit includes a discontinuous silt lense from approximately 5-15 ft below ground surface which extends over much of the site. Below this subunit is a second subunit consisting of dark grey to brown, sandy silt or silty clay of alluvial origin. This subunit appears to be continuous across the site and is believed to function as an aquitard in this sequence of river alluvium. The aquitard is from 20 to 40 ft thick (based on widely spaced borings).

Marine deposits are present below the aquitard and are composed of grey, slightly silty, sandy gravel and silty fine to coarse sand with an abundance of shell fragments. This unit defines the lower aquifer. Although this unit was not fully penetrated during this investigation, it is believed to be approximately 20 ft thick, based on the log of a 125-ft boring (Boring B2) which was located on the western edge of the site (Dames & Moore 1986). Boring B2 intercepted glacial till at approximately 103 ft below ground surface. Field methods are summarized in Appendix A.

Marine sediment core samples were collected at the locations shown on Figure 2-1. The depth intervals of core subsamples (e.g., 0.0-0.5 ft) are indicated in the sample designation, such as SD-J1-0.0-0.5. Logs of the core samples, based on visual observations at the time of sampling, are presented on Figures D-1 through D-8. Results of grain size analyses of selected samples are presented in a letter report by Soil Technology (see Appendix D). The sediments are commonly organic-rich silt and silty sands. Field methods are summarized in Appendix B.

5.2 GROUNDWATER FLOW

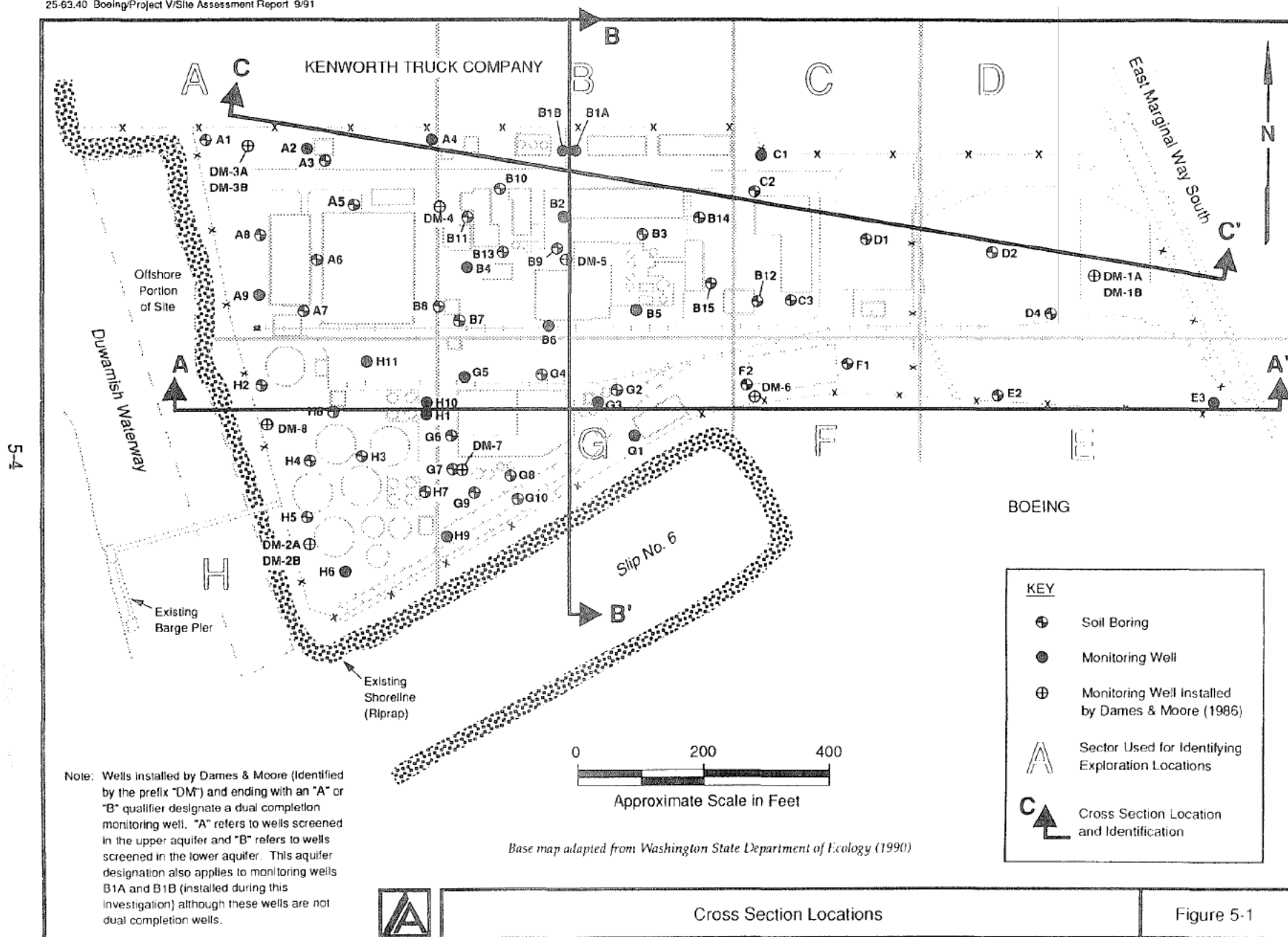
Groundwater levels at the site were measured in 26 upper aquifer monitoring wells and 4 lower aquifer monitoring wells at low and high tide. Monitoring well construction diagrams for the 19 wells installed during this investigation are presented in Appendix C. One offsite well, Well DC9-101-14E located approximately 2,200 ft southeast of the site at the Boeing Developmental Center, was also measured at the same time. Measurements were made from surveyed points at the top of the PVC well casings. The measuring point elevation and the water level measurements are presented in Table 5-1. Surveyed elevations are also presented in the surveyor's letter report in Appendix E.

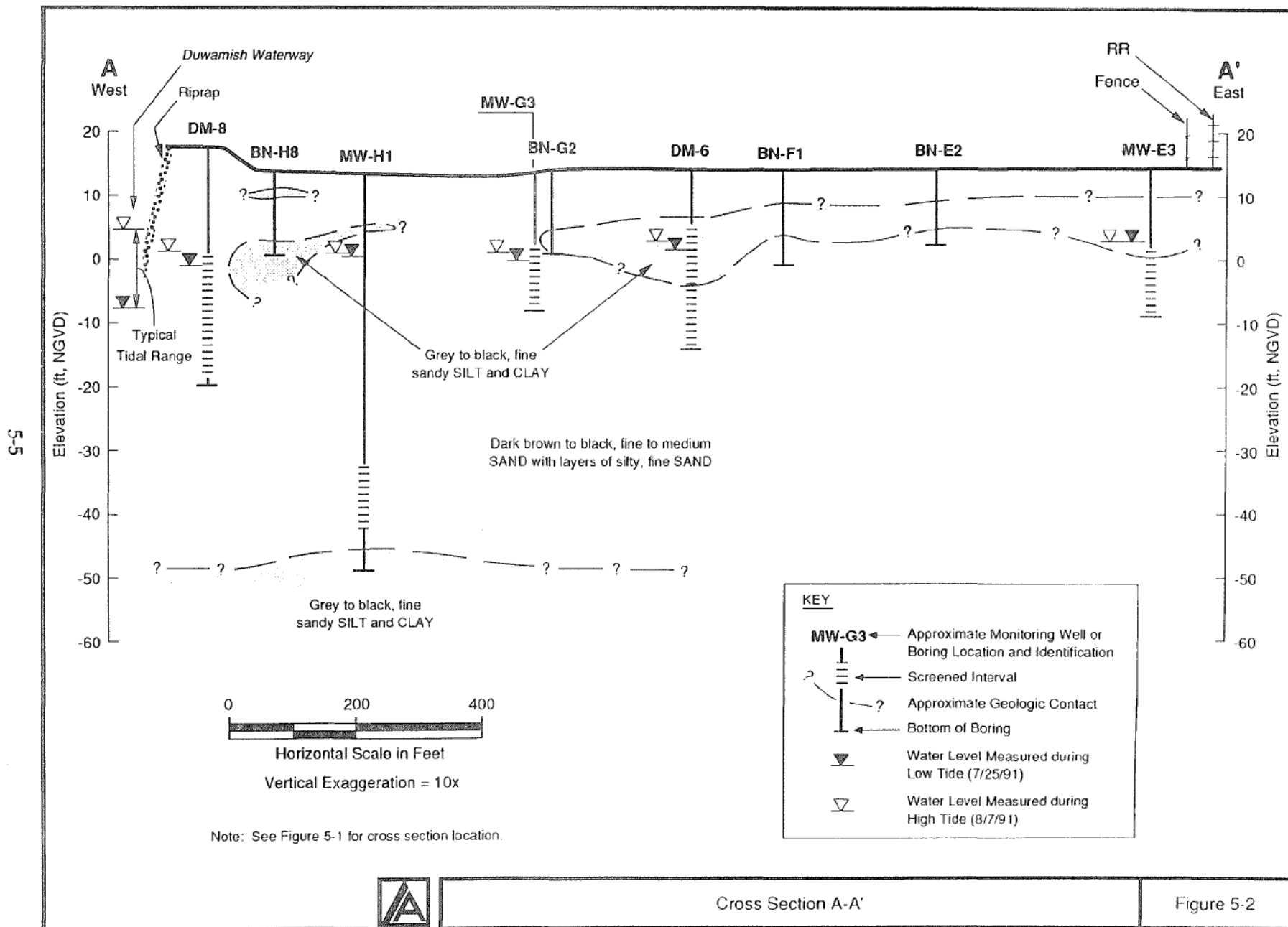
Groundwater was encountered in three different zones. The first zone consists of perched water above the silt layer at 5-15 ft below ground surface. Perched water was detected during drilling at only one location, Well B1A. Dames & Moore (1986) observed perched water during the drilling of Wells DM-4, DM-5, and DM-8. Although wet to saturated soil was encountered above the silt layer while drilling near these locations during this investigation, perched water was not observed. The perched water observed by Dames & Moore in DM-4 and DM-5 was black, and it was obviously associated with a release from the process area. It is likely that similar water was not observed during this investigation because either 1) plant operations had been shut down for approximately 4 months prior to this investigation, and therefore additional

recharge to the perched water zone did not occur, or 2) the observations made in 1986 were the result of a one-time release.

The second groundwater zone is referred to as the upper aquifer. Groundwater in the upper aquifer is unconfined and the groundwater surface is generally 12-15 ft below ground surface. Groundwater elevation contour maps for the upper aquifer are presented on Figures 5-5 and 5-6 for low and high tide, respectively. In the western portion of the site, groundwater flows toward the waterway and Slip No. 6 during low tide and toward the center of the site at high tide. Groundwater flow in the eastern portion of the site does not appear to be affected by tidal influences and maintains a constant westerly flow. Groundwater levels measured at high tide were up to 5.4 ft higher than at low tide in wells located near the waterway. The groundwater level measured in Well B1A was approximately 4-6 ft higher than in surrounding wells, due to the perched water condition and was, therefore, not used in constructing the groundwater elevation contour maps. The low tide measurement from Well B2 was also not used in constructing the low tide contour map because the well had not fully recharged from well development at the time the well was measured.

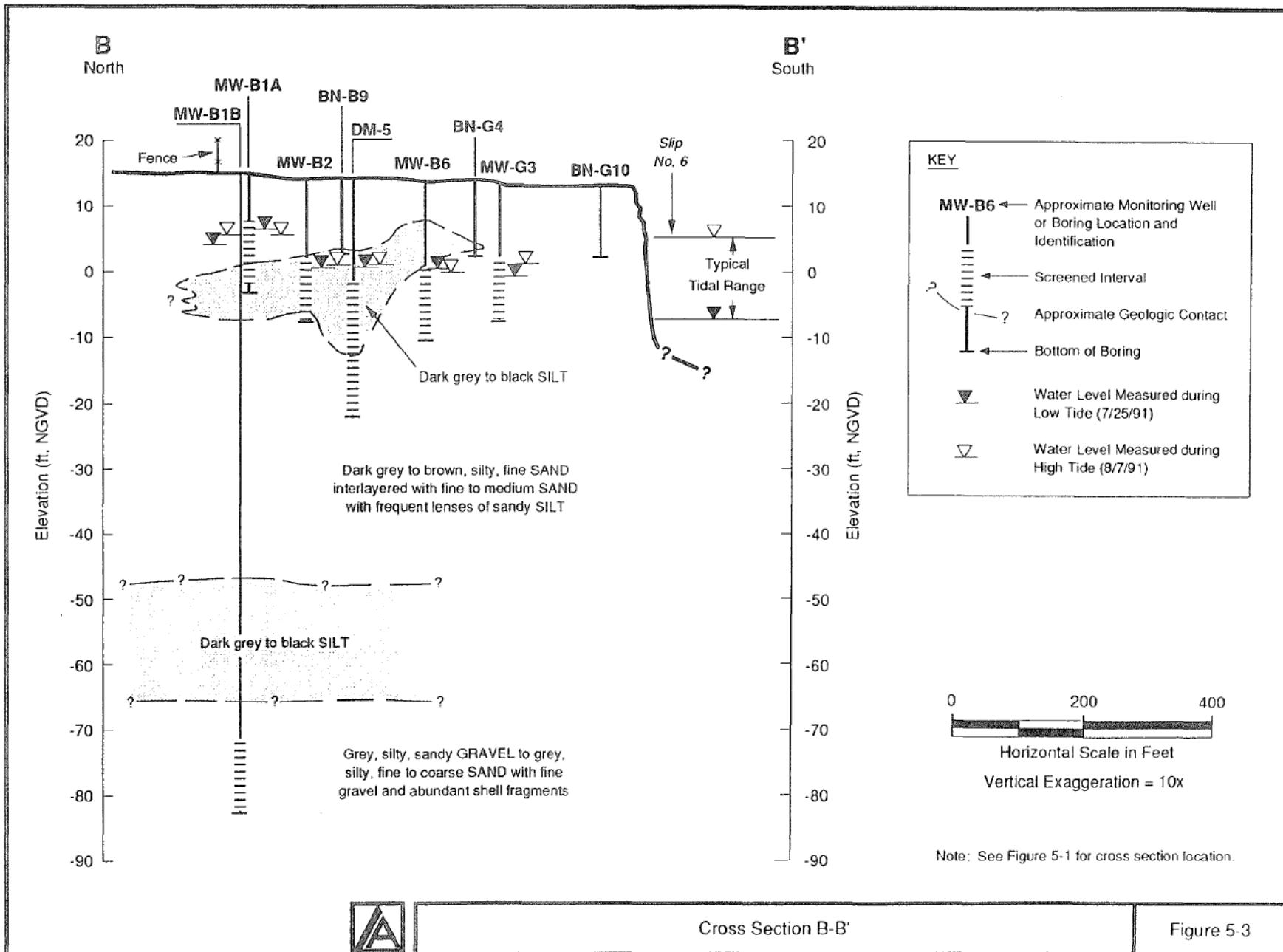
The third groundwater zone is referred to as the lower aquifer. Groundwater in the lower aquifer is confined and the potentiometric surface is generally 3-5 ft above the upper aquifer surface. Therefore, a vertical hydraulic gradient of approximately 0.1 to 0.2 in the upward direction (i.e., groundwater flows from the lower aquifer to the upper aquifer) exists at the site. Groundwater elevation contour maps for the lower aquifer are presented on Figures 5-7 and 5-8 for low and high tide, respectively. These maps indicate that groundwater flows in a westerly direction across the site at low tide and in a north to northeasterly direction at high tide. However, the groundwater elevation in the offsite well, DC9-101-14E, corresponding to high tide was below the elevations of the onsite wells which indicates that a divide exists between the site and the offsite well. Groundwater levels measured at high tide in Wells DM-2B and DM-3B, which are located at the western boundary of the site, were 5.46 and 4.60 ft, respectively, higher than levels measured at low tide, which indicates that groundwater levels in the lower aquifer are tidally influenced. This difference decreased in Wells B1B and DM-1B which are located farther to the east.





5-6

Monsanto 2A002458



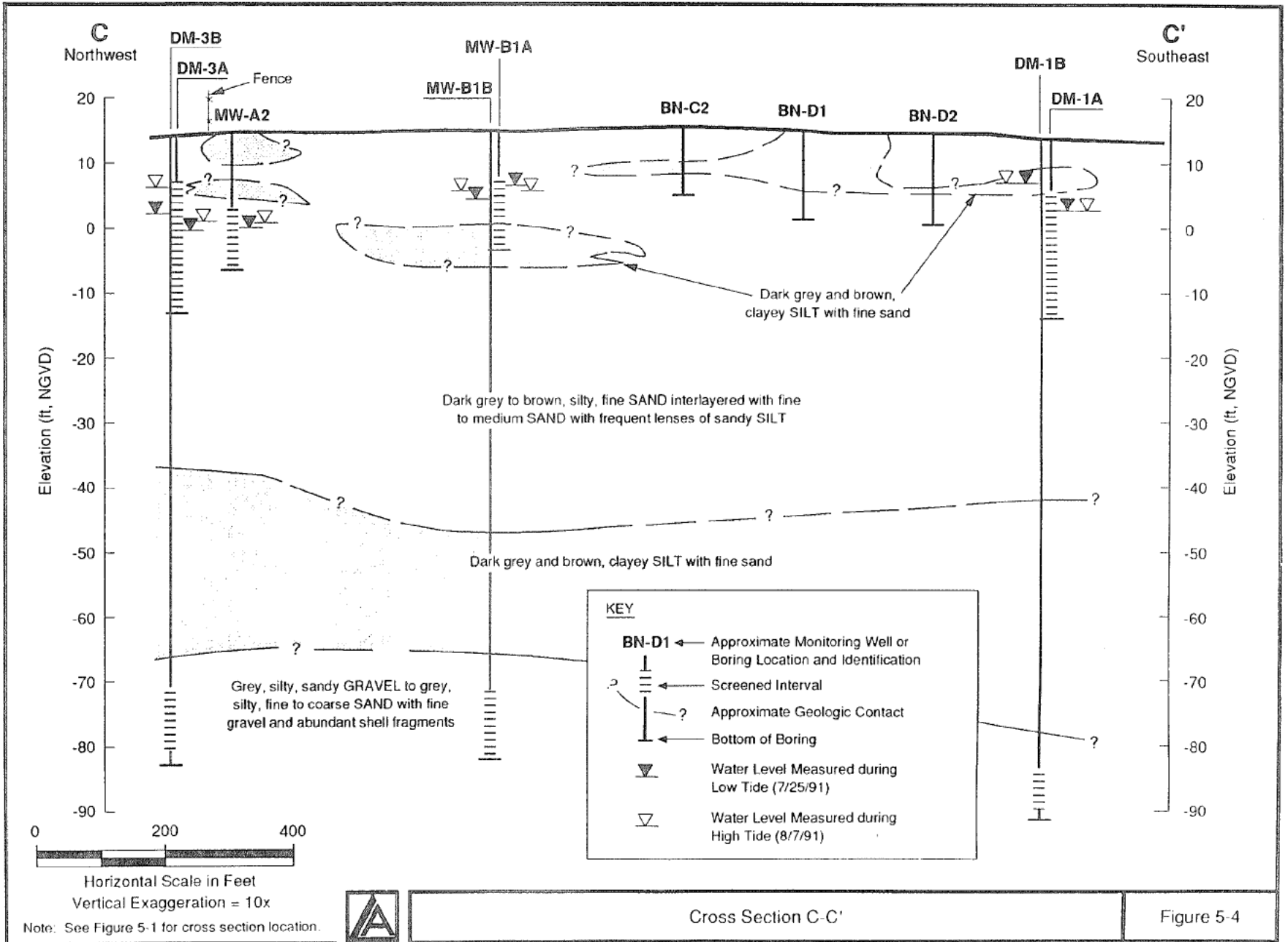
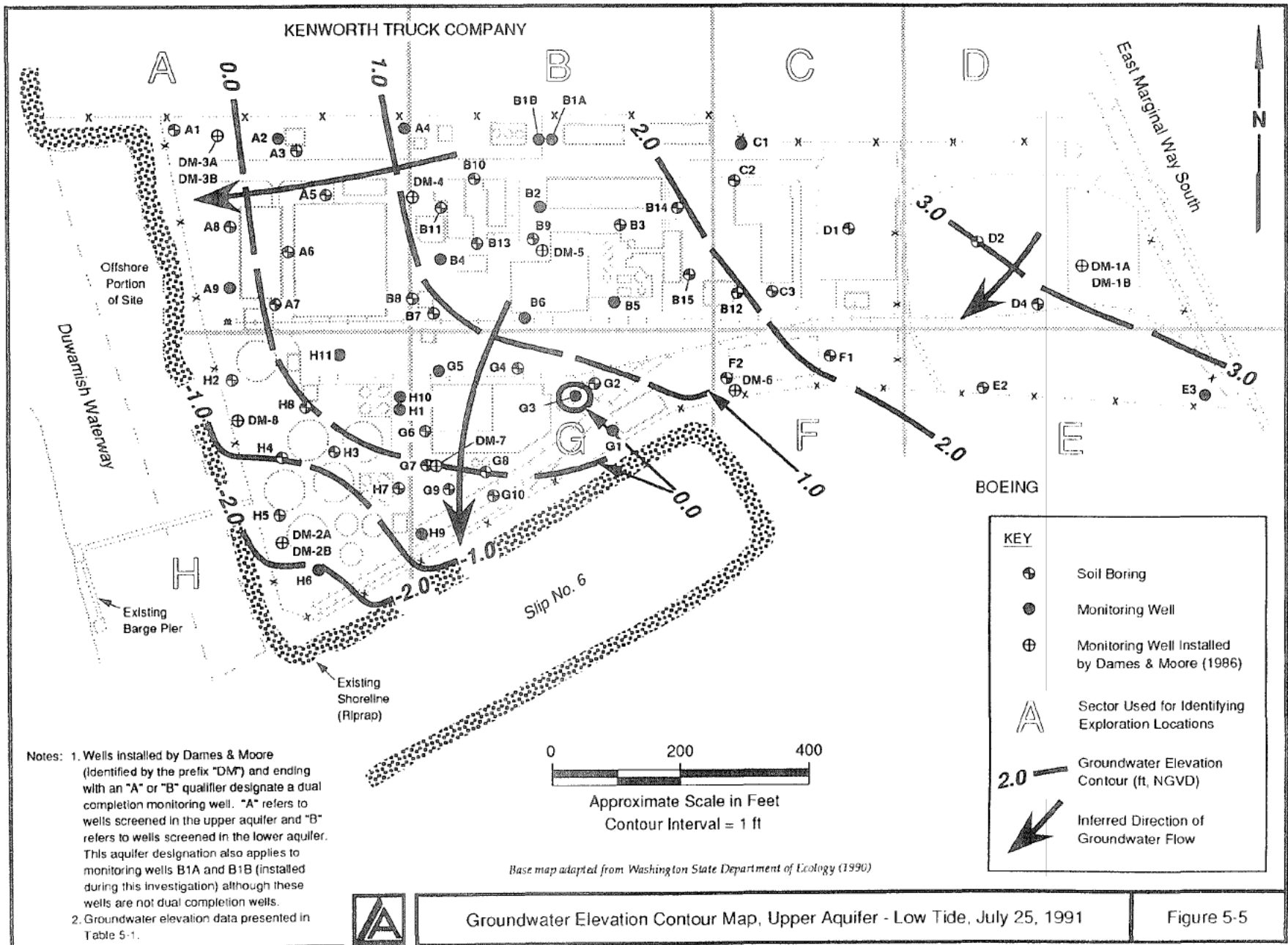
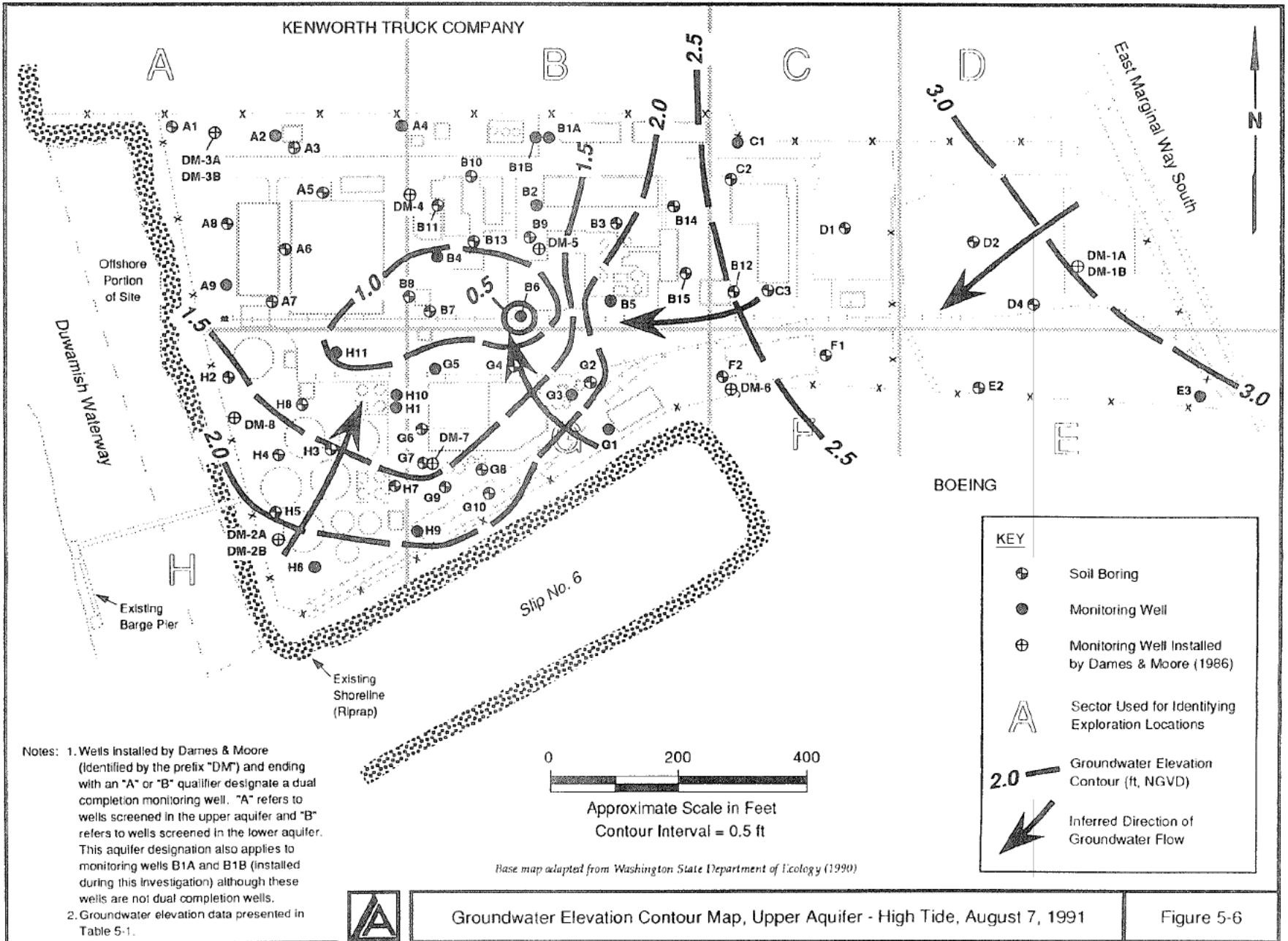


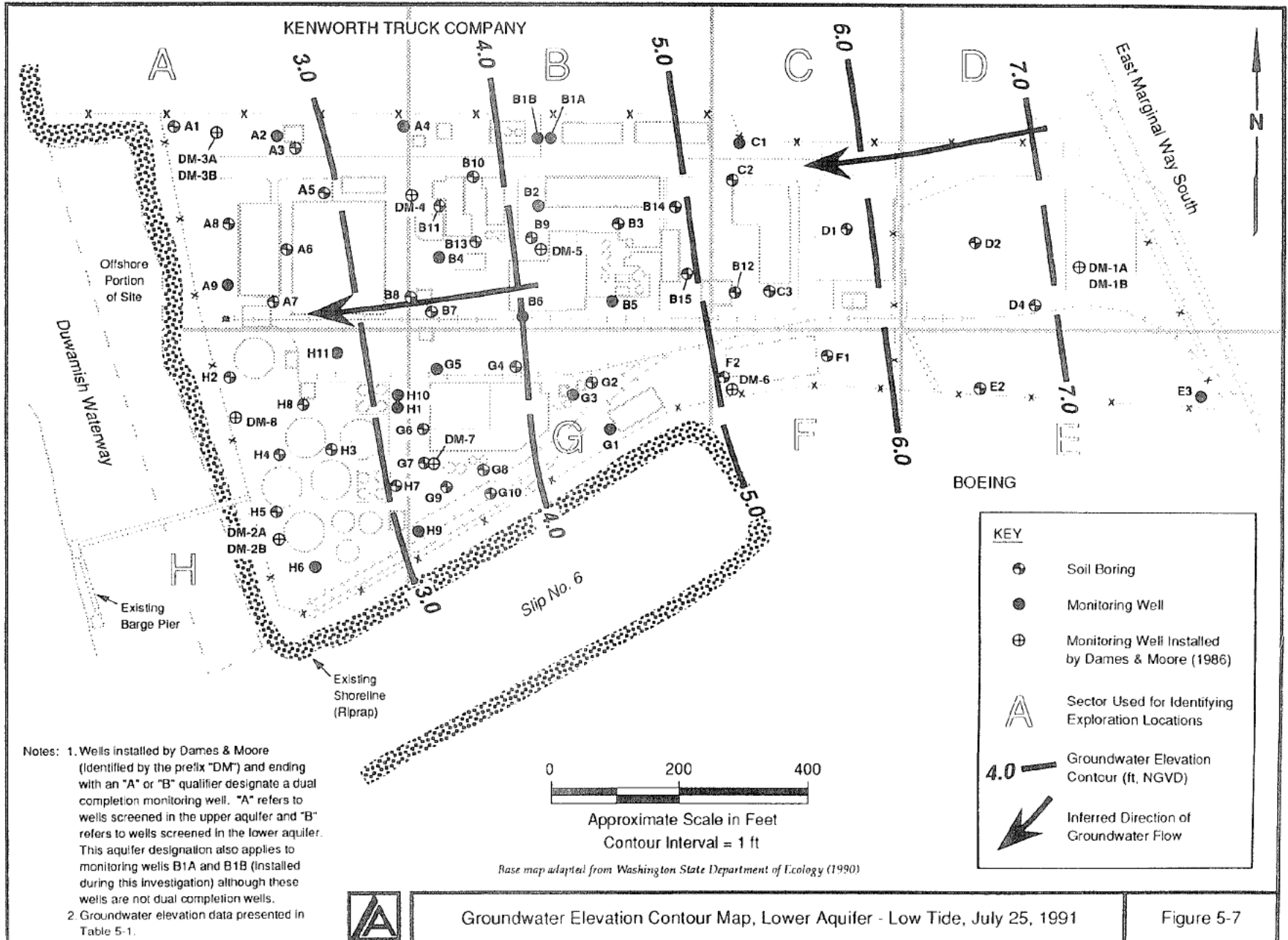
Figure 5-4

5-8

Monsanto 2A002460







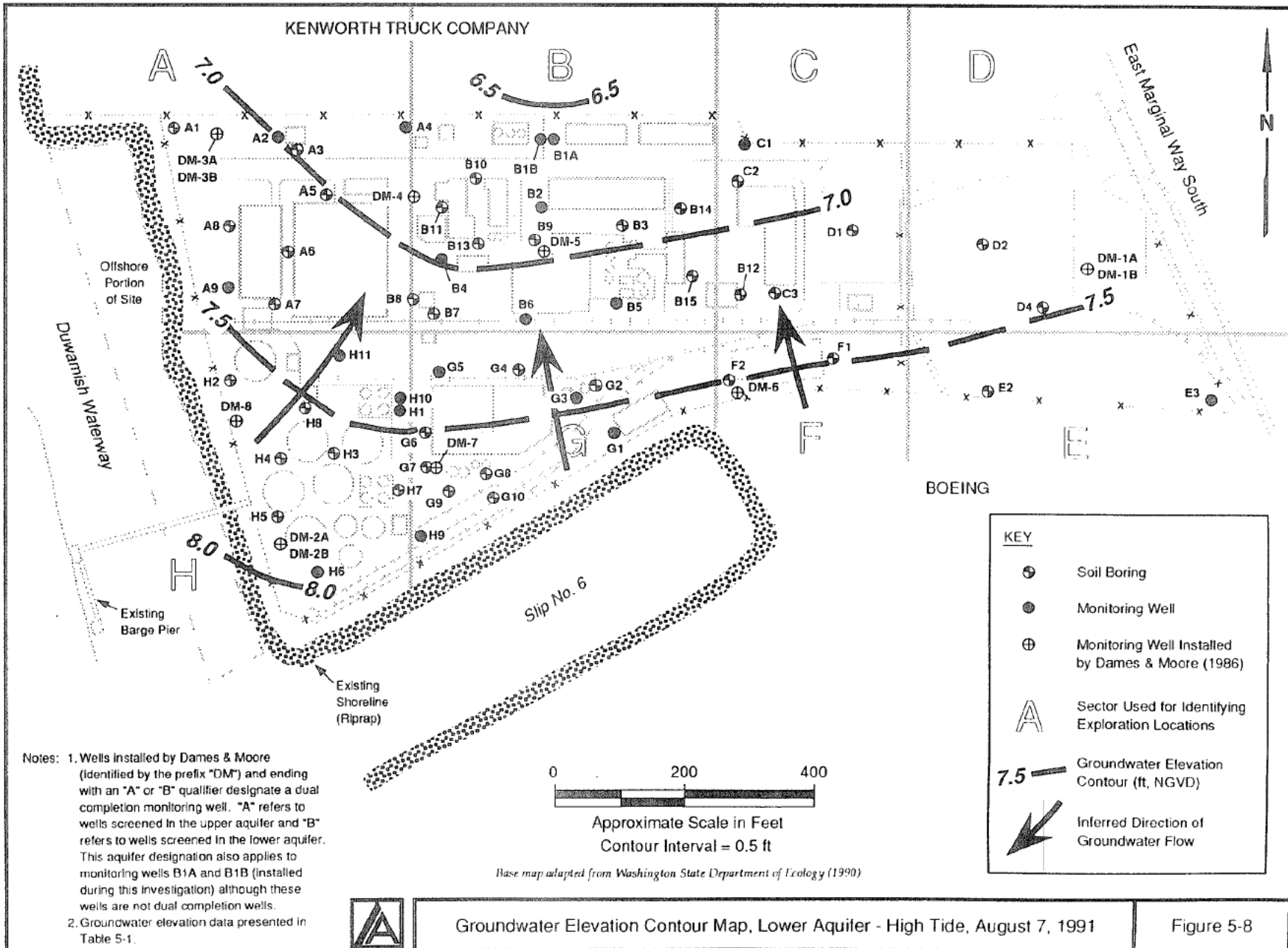


TABLE 5-1
MONITORING WELL AND GROUNDWATER ELEVATION DATA

Well No.	Measuring Point (Top of Casing) Elevation, ft NGVD	Ground Surface Elevation, ft NGVD	July 25, 1991 (a)		August 7, 1991 (b)	
			Depth to Water From Measuring Point (ft)	Groundwater Elevation, ft NGVD	Depth to Water From Measuring Point (ft)	Groundwater Elevation, ft NGVD
MW-A2	14.44	14.58	14.06	0.38	13.26	1.18
MW-A4	14.99	15.18	13.94	1.05	13.83	1.16
MW-A9	14.25	14.53	14.59	-0.34	12.90	1.35
MW-B1A	15.15	15.60	8.53	6.62	8.58	6.57
MW-B1B	14.75	15.09	10.58	4.17	8.17	6.58
MW-B2	13.88	14.14	12.92	0.96	12.69	1.19
MW-B4	13.81	14.33	12.75	1.06	12.83	0.98
MW-B5	13.85	14.07	12.10	1.75	11.59	2.26
MW-B6	13.82	14.08	12.76	1.06	13.80	0.02
MW-C1	14.71	14.92	12.18	2.53	12.11	2.60
MW-E3	14.56	14.62	11.71	2.85	11.74	2.82
MW-G1	13.04	13.33	12.18	0.86	10.79	2.25
MW-G3	13.64	13.81	13.83	-0.19	11.99	1.65
MW-G5	14.29	14.46	(c)	(c)	13.79	1.30 (d)
MW-H1	13.39	13.90	12.66	0.73	12.16	1.23
MW-H6	13.94	14.34	16.26	-2.32	10.82	3.12
MW-H9	13.50	13.85	13.94	-0.44	11.79	1.71
MW-H10	13.73	14.03	13.09	0.64	12.55	1.18
MW-H11	14.11	14.34	13.35	0.76	13.13	0.98
DM-1A	13.38	13.97	10.11	3.27	10.32	3.06
DM-1B	13.54	13.97	6.37	7.17	6.20	7.34
DM-2A	13.47	13.83	14.88	-1.41	11.43	2.04
DM-2B	13.62	13.83	11.20	2.42	5.74	7.88
DM-3A	13.96	14.19	14.23	-0.27	12.61	1.35
DM-3B	14.05	14.19	11.66	2.39	6.97	7.08
DM-4	13.86	14.45	12.89	0.97	12.74	1.12
DM-5	14.21	14.53	13.09	1.12	12.95	1.26
DM-6	14.70	14.00	12.98	1.72	12.25	2.45
DM-7	14.30	14.49	14.37	-0.07	12.88	1.42
DM-8	16.91	17.12	17.80	-0.89	15.25	1.66
DC9-101-14E	14.25	14.70	10.14	4.11	10.12	4.13

(a) Measurements were made during low tide (11:24 am-1:00 pm)

(b) Measurements were made during high tide (5:05 pm-6:50 pm).

(c) Questionable reading due to presence of over 2.8 ft of floating product.

(d) Groundwater elevation adjusted for the presence of floating product (measured at 0.89 ft of product, assumed a product specific gravity of 0.9).

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6.0 SCREENING CRITERIA EVALUATION

Current state and federal regulations do not define a simple mechanism to assess soil and groundwater quality data to determine whether a site may require remediation. Once a site has been reported to Ecology or EPA, an evaluation of the need for remediation is generally made during a multiphased site discovery and hazard assessment process. These evaluations consider constituent types and concentrations, source characteristics, exposure pathways, and the sensitivity of receptors. These evaluations rely, at least in part, on the professional judgment of those conducting the evaluations.

In the absence of a well-defined mechanism, the evaluation of the need for remedial action at the site was accomplished using conservative data screening techniques. These screening techniques take into consideration constituent concentrations as well as source characteristics, exposure pathways, and nature of receptors.

The screening approach involves the comparison of the data to established numerical criteria. Concentrations clearly below criteria values are dismissed as in need of no further evaluation, while concentrations at or above criteria are evaluated further to assess the nature of the exceedance. Exceedance or nonexceedance of numerical criteria, or screening criteria as they are referred in this report, alone does not determine whether a remedial action will be needed. Rather, the criteria serve as useful guidelines which, when combined with knowledge of source, pathways and receptors, help identify areas where remedial action may be warranted. Furthermore, the screening criteria are not specifically intended for use as cleanup levels if it is determined a remedial action is needed. Cleanup levels and points of compliance for the evaluation of specific remedial actions need to be developed separately.

The screening criteria for groundwater, soil, and marine sediments are discussed below. An evaluation of the potential need for remediation is presented in Section 7.0.

6.1 GROUNDWATER CRITERIA

The screening criteria for constituents detected in the groundwater samples are summarized in Table 6-1. The screening criteria consider the present and potential future use of the groundwater. At the present time, groundwater is not used as a source of drinking water at the site, and the location and zoning of the site and surrounding area suggest that use of near-surface groundwater aquifers as a drinking water source is unlikely. However, because MTCA states that evaluation of groundwater quality must consider the maximum beneficial use of the

groundwater, which at most sites is considered by MTCA to be drinking water, potential use as drinking water cannot be ignored. In addition, no precedent is available under the authority of recent state legislation to determine how groundwater in the vicinity of this site will be viewed in terms of potential future use. Therefore, the criteria selected for this screening level approach include the use of groundwater as a source of drinking water. The groundwater at this site also serves as a source of recharge to the Duwamish Waterway. Therefore, the potential impact of the site groundwater on the Duwamish Waterway has also been considered in developing the screening criteria.

The screening criteria listed in Table 6-1 are based on the most stringent of 1) drinking water standards for public water supplies which have been developed under the authority of the Federal Safe Drinking Water Act, 40 CFR 141, 142, and 143, and the State Board of Health, WAC 248-54, 2) cleanup standards for groundwater which have been developed under the authority of the Model Toxics Control Act (MTCA), WAC 173-340, and 3) aquatic life criteria developed pursuant to Section 304 of the Clean Water Act. Screening criteria were modified, as appropriate, to reflect background concentrations and constituent detection limits.

The drinking water standards include Primary Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs). MCLs represent enforceable concentrations of a contaminant developed based on human health effects in a public drinking water supply. SMCLs represent nonenforceable standards based on consideration of taste, color, and odor. Proposed MCLs (PMCL) and proposed SMCLs (PSMCL) are also available for several constituents. These are not promulgated standards and are only under consideration at this time. Table 6-1 summarizes all existing and proposed drinking water standards for constituents detected in groundwater at this site.

The MTCA cleanup standards are based on the highest beneficial use, which is assumed to be drinking water. Table 6-1 presents a summary of the MTCA compliance cleanup levels for detected constituents in groundwater listed in Table 1 (Method A) of the cleanup regulation. If neither a drinking water standard nor a MTCA Table 1 value existed for a constituent, a human health based concentration based on use of the groundwater as drinking water was calculated for the constituent. The calculated value was obtained by using Method B formulas provided in the MTCA cleanup regulation for groundwater as shown below. These calculations do not consider the influence of multiple compounds and multiple exposure pathways. Calculated values are also summarized in Table 6-1.

$$\text{Groundwater cleanup level (noncarcinogens)} = \frac{RfD \times ABW \times UCF \times HQ}{DWIR \times INH}$$

(µg/L)

where:

RfD	=	Reference Dose (mg/kg-day)
ABW	=	Average body weight during the period of exposure (16 kg)
UCF	=	Unit conversion factor (1,000 µg/mg)
HQ	=	Hazard quotient (1.0)
DWIR	=	Drinking water ingestion rate (1.0 liter/day)
INH	=	Inhalation correction factor.

$$\text{Groundwater cleanup level (carcinogens)} = \frac{RISK \times ABW \times LIFE \times UCF}{CPF \times DWIR \times DUR \times INH}$$

(µg/L)

where:

RISK	=	Acceptable cancer risk level (1 in 1,000,000)
ABW	=	Average body weight during the period of exposure (70 kg)
LIFE	=	Lifetime (75 years)
UCF	=	Unit conversion factor (1,000 µg/mg)
CPF	=	Carcinogenic potency factor (mg/kg-day)
DWIR	=	Drinking water ingestion rate (2.0 liters/day)
DUR	=	Duration of exposure (30 years)
INH	=	Inhalation correction factor.

Because site groundwater discharges to the Duwamish Waterway (a tidally influenced river), freshwater/marine aquatic life criteria (including criteria based on fish consumption) developed pursuant to Section 304 of the Clean Water Act were also considered in developing the screening criteria. Both freshwater and marine aquatic life criteria were considered and the most stringent criteria of all were used as the screening value because of the transitional status of the aquatic environment. Aquatic life criteria do not apply directly to groundwater but instead apply to the surface water body to which it discharges. Therefore, attenuation of groundwater constituents as the groundwater migrates to the surface water body will be considered in determining whether or not an exceedance of the aquatic criteria warrants remediation (Section 7.0). With the exception of fluoranthene and carcinogenic PAH, the aquatic criteria for organic constituents were higher (less stringent) than the drinking water criteria. The aquatic criteria for carcinogenic PAH (0.0311 ppb) was below the detection limits achieved on

the samples analyzed for PAH; therefore, the detection limit for carcinogenic PAH was used as the screening criteria (0.28 ppb).

The aquatic criteria for the metals that were detected onsite were either below detection limits (arsenic and cadmium), below background levels at the site (copper, nickel, and lead), above drinking water criteria (chromium, assuming aquatic criteria based on the level of trivalent chrome), or above detection limits and background values but below drinking water criteria (zinc). The screening criteria for arsenic and cadmium were therefore set equal to the detection limits which were 5 and 2 ppb, respectively. Background levels for copper, nickel, and zinc were determined by calculating the mean of the concentrations detected in Wells MW-C1, MW-E3, and DM-1A. These wells are upgradient of plant operation and do not appear to have been impacted by past practices at the site. Average background values were calculated to be 7 ppb, copper; 10 ppb, nickel; and 1.7 ppb, lead (the need for remediation takes into consideration that there will be natural exceedances of average background values). The screening criterion for chromium was based on drinking water and the screening criterion for zinc was set equal to the aquatic criterion, 59 ppb.

6.2 SOIL CRITERIA

Site cleanup standards for soil developed under the authority of the MTCA were selected as criteria for comparison to concentrations of constituents detected in site soil. Screening criteria for soil are summarized in Table 6-2. These values were obtained from Table 3 (Method A Cleanup Levels for Industrial Soil) in MTCA or, if a Method A value was not available, from procedures described in MTCA Method C for industrial soil. Method C describes several means for determining cleanup levels for industrial soil, including calculation of cleanup concentrations based on soil ingestion, and protection of groundwater. MTCA specifies that soil cleanup levels will be set at the most stringent of these values. The "default" method for determining levels for groundwater protection is accomplished by setting soil cleanup concentrations at 100x groundwater cleanup concentrations. A detailed demonstration based on soil types and constituent characteristics would need to be made in order to use a multiplier less stringent than 100. For purposes of data screening, the default value of 100 was used. However, a more detailed evaluation of constituent characteristics for those compounds which exceeded the screening criteria was made when assessing the need for remedial action (Section 7.0). In most cases, the most stringent cleanup levels obtained in Method C are based on protection of groundwater. These values are presented in Table 6-2.

6.3 MARINE SEDIMENT CRITERIA

Criteria which can be used to evaluate marine sediment quality include Washington State Sediment Management Standards (SMS, WAC 173-204) and the Puget Sound Dredged Disposal Analysis (PSDDA) program (U.S. Army Corps of Engineers et al. 1989). These criteria are summarized in Table 6-3. The SMS criteria require that analytical results for nonpolar organics be normalized using the total organic carbon (TOC) concentration for that sample; thus, the units for some of the criteria are in mg/kg TOC. Results for metals and polar organics may be compared without normalization. Marine sediment analytical results may be compared directly to PSDDA criteria. The sediment management standards for marine sediments are used herein; sediment management standards for low salinity sediments are currently being developed. When available, these standards will likely be applicable to this site.

Washington Department of Ecology Sediment Management Standards, WAC 173-204

The SMS include two sets of criteria which may be used to evaluate sediment quality. These are the Sediment Quality Standards and Minimum Cleanup Levels (Table 6-3). The Quality Standards correspond to "no significant health risk to humans" and "no acute or chronic adverse effects on biological resources." The concentrations of chemicals associated with the Minimum Cleanup Levels are generally greater than those associated with the Quality Standards. The cleanup screening methodology employs an average of chemical concentrations of several sample stations which comprise a "station cluster". Concentrations which are greater than Quality Standards but less than Minimum Cleanup Levels define the station clusters of which are "low concern." Concentrations greater than Minimum Cleanup Levels define station clusters of "potential concern" and may be designated as "cleanup sites."

PSDDA Screening Levels and Maximum Levels

The PSDDA program established criteria to determine whether sediments dredged from Puget Sound are suitable for unconfined, open-water disposal (U.S. Army Corps of Engineers et al. 1989). Sediments having constituent concentrations below a screening level (SL) are deemed suitable for such disposal. Sediments having constituent concentrations above a higher maximum level (ML) are unlikely to be suitable for such disposal, although biological testing may still be conducted to confirm the predictions of the ML. At contaminant concentrations between the SL and ML, biological testing would routinely be required to determine the suitability of the sediments for unconfined, open-water disposal. Therefore, although no

dredging is proposed, comparison of the concentrations of any contaminant found in sediments to the PSDDA SL and ML values serves as a useful initial screening of sediment quality.

TABLE 6-1

SCREENING CRITERIA - GROUNDWATER CONSTITUENTS

Detected Constituents	Federal Drinking Water Standards ^(a) (µg/L)	MTCA Compliance Cleanup Levels Table 1 ^(b) (µg/L)	Human Health Based Concentrations ^(c) (µg/L)	Freshwater/Marine Aquatic Life Criteria (µg/L) ^(d)	Screening Criteria Used in this Evaluation (µg/L)
<u>Inorganic Constituents</u>					
Arsenic	50 (MCL)	5	—	0.14 (FCO) (trivalent)	5 ^(e)
Cadmium	10 (MCL)	5	—	0.66 (FC)	2 ^(e)
Chromium	50 (MCL)	50	—	117 (FC) (trivalent)	50
Copper	1,000 (SMCL)	—	—	2.9 (MC)	7 ^(f)
Nickel	100 (PMCL)	—	—	8.3 (MC)	10 ^(f)
Lead	15 (AL)	5	—	1.32 (FC)	2 ^(f)
Zinc	5,000 (SMCL)	—	—	58.91 (FC)	59
<u>Volatile Organics</u>					
Acetone	—	—	800	—	800
Benzene	5 (MCL)	5	—	71.28 (FCO)	5
Chloroethane	—	—	Data inadequate	—	—
1,1-Dichloroethane	—	—	800	—	800
Formaldehyde	—	—	1.5	—	1.5
Toluene	1,000 (PMCL)	40	—	201,294 (FCO)	40
<u>Semivolatile Organics</u>					
Acenaphthene	—	—	960	—	960
Acenaphthylene	—	—	Data inadequate	—	—
Anthracene	—	—	4,800	107,692 (FCO)	4,800
Benzo(g,h,i)perylene	—	—	Data inadequate	—	—
Dibenzofuran	—	—	Data inadequate	—	—
Fluoranthene	—	—	640	374.6 (FCO)	374.6
Fluorene	—	—	640	14,358.5 (FCO)	640
2-Methylanthralene	—	—	Data inadequate	—	—
Naphthalene	—	—	64	—	64
Phenanthrene	—	—	Data inadequate	—	—
Pryene	—	—	480	10,769.2 (FCO)	480

TABLE 6-1

SCREENING CRITERIA - GROUNDWATER CONSTITUENTS

Detected Constituents	Federal Drinking Water Standards ^(a) (µg/L)	MTCA Compliance Cleanup Levels Table 1 ^(b) (µg/L)	Human Health Based Concentrations ^(c) (µg/L)	Freshwater/Marine Aquatic Life Criteria (µg/L) ^(d)	Screening Criteria Used in this Evaluation (µg/L)
Carcinogenic PAHs ^(g)	0.2 (PMCL)	0.1	–	0.0311 (FCO) ^(e)	0.28 ^(e)

– Criteria not available.

- (a) Federal Drinking Water Standards including maximum contaminant levels (MCL); secondary maximum contaminant levels (SMCL); proposed maximum contaminant levels (PMCL); proposed secondary maximum contaminant levels (PSMCL); and action level (AL) in lieu of an MCL.
- (b) Groundwater cleanup levels from the Model Toxics Control Act (MTCA), WAC 173-340-720, Table 1, Method A. February 28, 1991.
- (c) Human health based concentration calculated using the formulas specified in the text of this report. Concentrations calculated only for those compounds for which there were no federal drinking water standards or MTCA, Table 1 cleanup levels. The following chronic and reference dose (RfD) (mg/kg/day) and oral cancer potency factors (CPF) (mg/kg/day)⁻¹ were used: acetone RfD=0.1; 1,1-dichloroethane RfD=0.1; formaldehyde CPF=0.004; acenaphthene RfD=0.06; anthracene RfD=0.3; fluoranthene RfD=0.04; fluorene RfD=0.04; naphthalene RfD=0.004; and pyrene RfD=0.03. Compounds for which there were inadequate data to calculate human health based concentrations are noted in the table.
- (d) Freshwater/Marine Aquatic Life criteria are freshwater chronic (FC), marine chronic (MC), or fish consumption only (FCO). The most conservative (lowest) of all available criteria are listed. For calculations of freshwater aquatic life criteria a hardness of 50 mg/L (as CaCO₃, pH=6) was used.
- (e) Constituent detection limit is used as screening criterion.
- (f) Constituent background concentration is used as screening criterion.
- (g) Criteria are for total carcinogenic PAHs, which include Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene, Dibenz(a,h)anthracene, and Indeno(1,2,3-cd)pyrene.

REFERENCES:

Federal Drinking Water Standards

Federal Register, 52, (130), July 8, 1987.
Federal Register, (53), (160), August 18, 1988.
Federal Register, 54, (97), May 22, 1989.
Federal Register, 55, (143), July 25, 1990.
Federal Register, 55, (203), October 19, 1990.
Federal Register, 56, (20), January 30, 1991.

Aquatic Life Criteria

EPA Region IV, Toxic Substances Spreadsheet, February 25, 1991.

MTCA Cleanup Levels

Ecology 1991. Model Toxics Control Act, Chapter 173-340 WAC, February 28.

Human Health Based Concentrations

EPA 1991. Health Effects Assessment Summary Tables, Annual FY-1991.

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TABLE 6-2

SCREENING CRITERIA - SOIL CONSTITUENTS

Detected Constituents	MTCA Industrial Cleanup Levels Table 3 (mg/kg) ^(a)	100x MTCA Groundwater Human Health-Based Concentrations (mg/kg) ^(b)
<u>Inorganic Constituents</u>		
Arsenic	200	--
Cadmium	10	--
Chromium	500	--
Copper	--	64
Lead	1,000	--
Nickel	--	32
Zinc	--	320
<u>Volatile Organics</u>		
Acetone	--	80
Benzene	0.5	--
2-Butanone	--	40
Carbon Disulfide	--	80
1,2-Dichloroethene(cis)	--	8
Ethylbenzene	20	--
Toluene	40	--
1,1,1-Trichloroethane	20	--
Total Xylenes	20	--
<u>Semivolatile Organics</u>		
Acenaphthalene	--	96
Anthracene	--	480
Benzoic Acid	--	6,400
Benzo(ghi)perylene	--	Data inadequate
bis(2-ethylhexyl)phthalate	--	0.625
Dibenzofuran	--	Data inadequate
2-4-Dimethylphenol	--	32
Di-n-octylphthalate	--	32
Fluoranthene	--	64
Fluorene	--	64

TABLE 6-2

SCREENING CRITERIA - SOIL CONSTITUENTS

Detected Constituents	MTCA Industrial Cleanup Levels Table 3 (mg/kg) ^(a)	100x MTCA Groundwater Human Health-Based Concentrations (mg/kg) ^(b)
2-Methylnaphthalene	--	Data inadequate
2-Methylphenol	--	Data inadequate
4-Methylphenol	--	Data inadequate
Naphthalene	--	6.4
Pentachlorophenol	--	0.07
Phenanthrene	--	Data inadequate
Phenol	--	960
Pyrene	--	48
Carcinogenic PAHs ^(c)	20	

(a) Industrial soil cleanup levels from the Model Toxics Control Act (MTCA), WAC 173-340-745, Table 3, Method A. February 28, 1991.

(b) Criteria for protection of groundwater were calculated using the Method B groundwater cleanup level formula (MTCA, WAC 173-340-720, Method B) and multiplying the resulting concentration times 100 to derive a soil cleanup value. The following chronic oral reference doses (RfD) (mg/kg/day) and oral cancer potency factors (CPF) (mg/kg/day)⁻¹ were used: copper RfD=0.04; nickel RfD=0.02; zinc RfD=0.2; acetone RfD=0.1; 2-butanone RfD=0.05; carbon disulfide RfD=0.1; 1,2-dichloroethene(c) RfD=0.01; acenaphthalene RfD=0.06; anthracene RfD=0.3; benzoic acid RfD=4; bis(2-ethy(hexyl)phthalate PF=0.014; 2,4-dimethylphenol RfD=0.02; di-n-octylphthalate RfD=0.02; fluoranthene RfD=0.04; fluorene RfD=0.04; naphthalene RfD=0.004; pentachlorophenol PF=0.12; phenol RfD=0.6; and pyrene RfD=0.03. Compounds for which there were inadequate data to calculate human health based concentrations are noted as "Data inadequate".

(c) Criteria are for total carcinogenic PAHs which include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene.

REFERENCES:

WAC 173-340.

EPA 1991. Health Effects Assessment Summary Tables, Annual FY-1991.

TABLE 6-3

SCREENING CRITERIA - MARINE SEDIMENT CONSTITUENTS

	Sediment Management Standards ^(a)				PSDDA ^(b)	
	Sediment Quality Standards		Minimum Cleanup Levels		Screening Level	Maximum Level
	dry wt	as TOC	dry wt	as TOC	(SL)	(ML)
METALS	(mg/kg)		(mg/kg)		(mg/kg)	(mg/kg)
Antimony	-- ^(c)	--	--	--	20	200
Arsenic	57	--	93	--	57	700
Cadmium	5.1	--	6.7	--	0.96	9.6
Chromium	260	--	270	--	--	--
Copper	390	--	390	--	81	810
Lead	450	--	530	--	66	660
Mercury	0.41	--	0.59	--	0.21	2.1
Nickel	--	--	--	--	140	--
Silver	6.1	--	6.1	--	1.2	6.1
Zinc	410	--	960	--	160	1,600
Tributyl Tin	--	--	--	--	30	--
ORGANIC COMPOUNDS		(mg/kg)		(mg/kg)	(µg/kg)	(µg/kg)
<u>Low Molecular Weight PAH</u>	--	370	--	780	610	6,100
Naphthalene	--	99	--	170	210	2,100
Acenaphthylene	--	66	--	66	64	640
Acenaphthene	--	16	--	57	63	630
Fluorene	--	23	--	79	64	640
Phenanthrene	--	100	--	480	320	3,200
Anthracene	--	220	--	1200	130	1,300
2-Methylnaphthalene	--	38	--	64	67	670
<u>High Molecular Weight PAH</u>	--	960	--	5300	1,800	51,000
Fluoranthene	--	160	--	1200	630	6,300
Pyrene	--	1,000	--	1400	430	7,300
Benzo(a)anthracene	--	110	--	270	450	4,500
Chrysene	--	110	--	460	670	6,700
Benzo(a)fluoranthene	--	230	--	450	800	8,000
Benzo(a)pyrene	--	99	--	210	680	6,800
Indeno(1,2,3-c,d)pyrene	--	34	--	88	69	5,200
Dibenz(a,h)anthracene	--	12	--	33	120	1,200
Benzo(g,h,i)perylene	--	31	--	78	540	5,400

TABLE 6-3

SCREENING CRITERIA - MARINE SEDIMENT CONSTITUENTS

	Sediment Management Standards ^(a)				PSDDA ^(b)	
	Sediment Quality Standards		Minimum Cleanup Levels		Screening Level (SL)	Maximum Level (ML)
	dry wt	as TOC	dry wt	as TOC		
<u>Chlorinated Organic Compounds</u>		(mg/kg)		(mg/kg)	(µg/kg)	(µg/kg)
1,3-Dichlorobenzene	--	--	--	--	170	--
1,4-Dichlorobenzene	--	3.1	--	9	26	260
1,2-Dichlorobenzene	--	2.3	--	2.3	19	350
1,2,4-Trichlorobenzene	--	0.81	--	1.8	6.4	64
Hexachlorobenzene	--	0.38	--	2.3	23	230
Total PCBs	--	12	--	65	130	2,500
<u>Phthalates</u>						
Dimethyl Phthalate	--	53	--	53	160	--
Diethylphthalate	--	61	--	110	97	--
Di-n-butylphthalate	--	220	--	1700	1,400	--
Butylbenzylphthalate	--	4.9	--	64	470	--
bis(2-Ethylhexyl)Phthalate	--	47	--	78	3,100	--
Di-n-octyl Phthalate	--	58	--	4500	6,200	--
<u>Phenols</u>		(µg/kg)		(µg/kg)	(µg/kg)	(µg/kg)
Phenol	420	--	1200	--	120	1,200
2-Methylphenol	63	--	63	--	10	72
4-Methylphenol	670	--	670	--	120	1,200
2,4-Dimethylphenol	29	--	29	--	10	50
Pentachlorophenol	360	--	690	--	69	690
<u>Miscellaneous Extractables</u>						
Benzyl alcohol	57	--	73	--	10	73
Benzoic acid	650	--	650	--	216	690
Dibenzofuran	--	15	--	58	54	540
Hexachloroethane	--	--	--	--	1,400	14,000
Hexachlorobutadiene	--	3.9	--	6.2	29	290
N-Nitrosodiphenylamine	--	11	--	11	22	220

TABLE 6-3

SCREENING CRITERIA - MARINE SEDIMENT CONSTITUENTS

	Sediment Management Standards ^(a)				PSDDA ^(b)	
	Sediment Quality Standards		Minimum Cleanup Levels		Screening Level	Maximum Level
	dry wt	as TOC	dry wt	as TOC	(SL)	(ML)
<u>Volatile Organics</u>					(µg/kg)	(µg/kg)
Trichloroethene	--	--	--	--	160	1,600
Tetrachloroethene	--	--	--	--	14	210
Ethylbenzene	--	--	--	--	10	50
Total xylenes	--	--	--	--	12	160
<u>Pesticides</u>					(µg/kg)	(µg/kg)
Total DDT	--	--	--	--	6.9	69
p,p'-DDE	--	--	--	--	--	--
p,p'-DDD	--	--	--	--	--	--
p,p'-DDT	--	--	--	--	--	--
Aldrin	--	--	--	--	10	--
Chlordane	--	--	--	--	10	--
Dieldrin	--	--	--	--	10	--
Heptachlor	--	--	--	--	10	--
Lindane	--	--	--	--	10	--

- (a) The Washington State Department of Ecology has established these Sediment Management Standards WAC 173-204. The criteria for metals (mg/kg dry weight, ppm) and polar organic compounds (µg/kg dry weight, ppb) are on a dry weight basis. The criteria for non-polar organic compounds are on a TOC-normalized basis (mg/kg as organic carbon).
- (b) The Puget Sound Dredged Disposal Analysis (PSDDA) program established these screening levels (SLs) and maximum levels (MLs). Metals in mg/kg dry weight; organic compounds in µg/kg dry weight. Source: U.S. Army Corps of Engineers et al. (1989).
- (c) "--" indicates no criteria are promulgated for respective chemical compound.

7.0 FINDINGS AND REMEDIATION ASSESSMENT

7.1 GENERAL

This section evaluates the results of the chemical testing of soil, groundwater, and sediments. The results of chemical testing are summarized by media in Appendix F. The laboratory data sheets are presented in Appendix J, Volumes 2 and 3 of this report. Quality assurance validation of the chemical data is presented in Appendix G. The results of field testing of groundwater samples for pH, specific conductance, and temperature are presented in Table 7-1.

The evaluation of the chemical data includes a comparison of detected constituents to screening criteria developed in Section 6.0. Following this evaluation, an assessment is made as to whether or not remediation of those constituents that exceeded the screening criteria would likely be required by the agencies. In many cases, this determination is based on best professional judgment and does not involve a direct comparison of the detected levels to the screening criteria. Factors used in making these determinations are presented later in this section. It is important to note that the remediation determination has not been discussed with or approved by Ecology. Where remediation is determined to be necessary in a given area, various potential remediation technologies and estimated remediation costs for that area are presented in Section 8.0.

This section of the report is divided into six areas of the site based on similarity in chemical results within the area or onsite use:

- MW-G5 Plume Area
- Sectors A and B (Production Area)
- Sector H (Liquid Storage Area)
- Sectors C, D, E, F, and G
- Black Liquid Plume
- Offshore Property.

7.2 MW-G5 PLUME AREA

The MW-G5 plume area includes the areas shown on Figures 7-1 and 7-2. The MW-G5 plume area delineates an area of very high toluene concentrations in soil (Figure 7-1) and groundwater (Figure 7-2).

7.2.1 Soil Quality

Toluene was detected in all soil samples collected at each of the three drilling locations within the MW-G5 Plume Area. (Note MW-H1 and MW-H10 are located adjacent to each other and are considered one location in evaluating soil quality.) Exceedance of the 40,000 ppb toluene screening criterion occurred in two samples from MW-G5, five from MW-H1, and three from MW-H11 (Figure 7-1). The maximum concentration measured was 28,000,000 ppb in the 2.5-ft sample from MW-H1. All exceedances occurred in samples collected at or above the groundwater surface.

The presence of high levels of toluene in soil samples collected above the groundwater surface in MW-H1 and MW-H11 indicates that the toluene release likely occurred from the surface in these areas. The absence of high toluene levels in samples collected above the groundwater surface in MW-G5 indicates that lateral migration of toluene in the groundwater is the likely toluene source in MW-G5 soil samples. Potential release sources of toluene in this area include the aboveground storage tanks located immediately to the west of MW-H1 (which reportedly stored toluene) and the underground toluene line which carried toluene from the storage tanks to the vanillin production area. It was reported that a leak developed in the toluene line somewhere between the tanks and the production area and, as a result, the line was taken out of service. The volume of toluene released is not known.

A summary of constituents that exceeded the screening criteria for soil in this area is presented in Table 7-2. In addition to toluene, other constituents that exceeded the soil screening criteria in the MW-G5 area are ethylbenzene, acetone, pentachlorophenol, and bis(2-Ethylhexyl)Phthalate. Other constituents found in soil sampled from this area include 2-butanone, xylenes, methylphenols and PAH, however, none of these occurrences exceeded screening criteria or screening criteria could not be developed for the constituent based on existing toxicological information (Section 6.0).

7.2.2 Groundwater Quality

Three shallow (approximately 20 ft) monitoring wells (MW-G5, H10, and H11) and one deep (approximately 50 ft) monitoring well (MW-H1) are located within the MW-G5 Plume area. All of these wells are screened in the upper aquifer. Toluene was found in each of the three shallow monitoring wells at levels that exceeded the screening criteria (40 ppb). The estimated extent of the toluene plume and the measured concentrations are shown on Figure 7-2. Floating product (also commonly referred to as Light Nonaqueous Phase Liquid or LNAPL) was

measured in MW-G5 on each of three separate occasions. The results of these measurements are shown below:

<u>Date</u>	<u>Tide</u>	<u>Measured Thickness (inches)</u>
07/25/91	Low	>33
08/07/91	High	8
08/21/91	Low	24

As shown above, the measured thickness is greatest at low tide. The color of the LNAPL is reddish brown. A sample of the LNAPL was submitted to the laboratory for identification of product type; the preliminary results from this analysis indicate that the LNAPL is either toluene or diesel. Additional testing of the sample is currently underway. Toluene was not detected in the sample from MW-H1 which indicates that in the immediate vicinity of this well, the presence of toluene in groundwater is limited to the upper portion of the aquifer.

A summary of constituents that exceeded the screening criteria for groundwater in this area is presented in Table 7-2. In addition to toluene, these include acetone, carcinogenic PAH, arsenic, chromium, nickel, copper, and lead. The temperature of groundwater from MW-H10 was recorded as 36.3°C (97.3°F) (see Table 7-1). The elevated temperature in this well and probably MW-H1 is likely the result of a break in an underground steam line that occurred less than 20 ft from the location of these wells. The line was shut down approximately 1 month prior to groundwater sampling.

7.2.3 Remediation Assessment

Remediation of toluene in both soil and shallow groundwater will likely be required in this area based on the level at which the screening criteria were exceeded, the widespread presence of toluene in the area, and the presence of what is believed to be free toluene product in MW-G5. Potential remediation technologies and cost estimates are presented in Section 8.0. The chromium exceedance appears to be related to the presence of the black liquid plume and is therefore discussed in Section 7.6. Remediation of conditions specifically for other constituents that exceeded the screening criteria was determined to be unlikely based on the following:

- Acetone and Ethylbenzene: will be remediated along with toluene in the soil and groundwater
- Carcinogenic PAH: exceeded criteria in only one groundwater sample, extremely low levels present

- Pentachlorophenol: exceeded criteria based on groundwater protection in only two soil samples, concentrations less than 1 ppm which is the proposed cleanup level for pentachlorophenol in soil, criterion is based on very conservative assumptions
- bis(2-Ethylhexyl)Phthalate: is a common plasticizer and laboratory contaminant, unlikely to trigger the need for remediation by itself; criteria are based on very conservative assumptions
- Arsenic: levels detected are relatively low, positively detected in only one sample
- Chromium: see discussion in Section 7.6
- Nickel and Lead: slight exceedance of aquatic criteria only, consideration of attenuation would likely result in nonexceedance at waterway
- Copper: exceedance of aquatic criteria only, consideration of attenuation would likely result in nonexceedance at waterway.

7.3 SECTORS A AND B (PRODUCTION AREA)

7.3.1 Soil Quality

Toluene was detected in 26 out of 39 samples from Sector A and 58 out of 65 soil samples collected from Sector B. The screening criteria for toluene (40,000 ppb) was exceeded in five samples, four from Boring B13 and one from Boring B11. The highest toluene concentration in this area was measured in the 2.5 ft sample from B13 (5,400,000 ppb). Sector B includes the vanillin production area where toluene was extensively used as a solvent for extracting vanillin.

In addition to toluene, other constituents which exceeded the soil screening criteria included pentachlorophenol, bis-(2-Ethylhexyl)Phthalate, copper, and nickel. Exceedances of the soil screening criteria for Sectors A and B are summarized in Table 7-3. The exceedance of the copper screening criterion in five samples (Table 7-3) is likely related to the use of copper sulfate as a raw material in vanillin production. The presence of pentachlorophenol may be related to the production of wood preservatives at the site in the 1930s and 1940s (Section 3.0).

7.3.2 Groundwater Quality

Toluene was detected in only one well in this area, MW-B6. The detected level was below the groundwater screening criterion. Constituents which exceeded the groundwater screening criteria include benzene, formaldehyde, carcinogenic PAH, arsenic, chromium, copper, and nickel. Exceedances of the groundwater screening criteria are summarized in Table 7-3. Benzene was detected in only one well (MW-B5) at a concentration just slightly above the screening criteria.

The solvent 1,1-dichloroethane (1,1-DCA) was detected in wells DM-3A and MW-A2, which are both located in the northwest corner of the site. A potential source of the solvent is the Kenworth plant which borders the Rhone-Poulenc property to the north. This same solvent was detected at elevated levels in several wells on the Kenworth property (GeoEngineers 1988). Based on current groundwater elevation data, the northwest corner of the Rhone-Poulenc property appears to be the only portion of the property that is downgradient of the Kenworth plant. The detected levels of 1,1-DCA (2.9-9.7 ppb) were well below the screening criterion (800 ppb).

7.3.3 Remediation Assessment

Remediation of toluene in Sector B soil will likely be required based on the level at which the screening criterion was exceeded, the widespread occurrence of toluene in this area, and on the likelihood of finding toluene in areas that are currently occupied by structures and were therefore not investigated. Potential remedial technologies and cost estimates are presented in Section 8.0. Remediation of copper in Sector B soil is considered to have a low likelihood based on the low level at which the screening criterion was exceeded in most of the samples and the relatively low level of copper in groundwater. However, the copper condition in Sector B should be given additional consideration due to the level of copper found in B6-5.0, the extent of copper in Sector B, and the fact that the presence of copper can be related to site activities. The chromium exceedance appears to be related to the presence of the black liquid plume (see Section 7.6). Remediation of the other constituents which exceeded screening criteria in soil and groundwater was determined to be unlikely based on the following:

- Benzene and formaldehyde: detected in groundwater in only one well and at levels slightly above the screening criteria
- Carcinogenic PAH: detected in groundwater in only one well at a level slightly above the screening criterion

- Pentachlorophenol: positively detected in only one soil sample at less than 1 ppm, which is the proposed cleanup level for pentachlorophenol in groundwater; detection appears to be an isolated occurrence, criterion are based on very conservative assumptions
- bis-(2-ethylhexyl)Phthalate: a common plasticizer and laboratory contaminant, unlikely to trigger the need for remediation by itself; criterion are based on very conservative assumptions
- Arsenic: levels detected are relatively low
- Chromium: see discussion in Section 7.6
- Nickel: isolated exceedance in soil, aquatic criteria slightly exceeded in groundwater, consideration of attenuation would likely result in a nonexceedance at waterway.

7.4 SECTOR H (LIQUID STORAGE AREA)

7.4.1 Soil Quality

Toluene was detected in 24 of 27 soil samples collected in Sector H, however, most of the detections were below 10 ppb and none of the detections exceeded screening criterion. Only two constituents exceeded the soil screening criteria in Sector H; copper and nickel. Both of these constituents were detected in only one sample. Exceedances of the soil screening criteria are summarized in Table 7-4.

7.4.2 Groundwater Quality

Toluene was detected in Wells DM-2A and DM-2B which are flush mounted, dual completion monitoring wells. DM-2B is screened in the lower aquifer. Both detections were less than 5 ppb and thus did not exceed screening criterion. It appears that the toluene entered DM-2B from the surface and therefore the presence of toluene in this well does not indicate that toluene has migrated through the upper aquitard into the lower aquifer. The wells are located inside of a large concrete-bermed area that surrounds the aboveground storage tanks in Sector H. During Landau Associate's initial inspection of the site, the steel cover of the well monument was removed to inspect the wells. Black liquid, likely related to the black sulfite liquor used in vanillin production, was pooled inside the monument to a level equal to the top of the two PVC casings. The inside of the PVC casings was stained black. It is believed that a release from one of the storage tanks was contained within the bermed area and a portion of the liquid flooded

the monument and entered the PVC casings. Neither casing was equipped with a watertight seal. Black liquid was present in both wells during groundwater sampling (see Section 7.6).

Constituents detected in Sector H that exceeded the groundwater screening criteria include arsenic, chromium, copper, and nickel. Exceedances of the groundwater screening criteria are summarized in Table 7-4.

7.4.3 Remediation Assessment

Although copper exceeds the screening criterion in several wells in Sector H and the close proximity of Sector H to the waterway will minimize the effects of attenuation (as demonstrated by the exceedance of the copper screening criteria in Seeps 1 and 2), the likelihood that remediation will be required is considered low because the levels present are relatively low. The chromium exceedances appear to be related to the presence of the black liquid plume (see Section 7.6). Remediation of the other constituents which exceeded the screening criteria was determined to be unlikely based on the following:

- Chromium (see discussion in Section 7.6)
- Arsenic: levels detected are relatively low and may be background issue
- Nickel: isolated exceedance in soil, aquatic criteria slightly exceeded in groundwater; consideration of attenuation would likely result in a nonexceedance at waterway.

7.5 SECTORS C, D, E, F, AND G

(Note: The MW-G5 area is not included in these sectors.)

7.5.1 Soil Quality

Toluene was detected in 65 of 91 soil samples collected in this area, however, most of the detections were below 10 ppb and none of the detections exceeded screening criterion. Pentachlorophenol was the only constituent which exceeded the soil screening criteria in this area. Exceedances of the soil screening criteria are summarized in Table 7-5.

7.5.2 Groundwater Quality

Toluene was not detected in any of the wells within this area. Constituents which exceeded the groundwater screening criteria include arsenic, chromium, copper, cadmium, and lead. Exceedances of the criteria are summarized in Table 7-5.

7.5.3 Remediation Assessment

The chromium exceedance appears to be related to the presence of the black liquid plume (see Section 7.6). Remediation of the other constituents which exceeded the screening criteria was determined to be unlikely based on the following:

- Pentachlorophenol: positively detected in only one soil sample at less than 1 ppm, which is the proposed cleanup level for pentachlorophenol in soil; detection appears to be an isolated occurrence, criterion are based on very conservative assumptions
- Chromium (see discussion in Section 7.6)
- Arsenic: levels detected are relatively low
- Copper, cadmium, and lead: aquatic criteria slightly exceeded in groundwater, consideration of attenuation would likely result in a nonexceedance at the waterway.

7.6 BLACK LIQUID PLUME

7.6.1 Groundwater Quality

The black liquid plume includes the area delineated on Figure 7-3 where samples from the monitoring wells appeared dark brown to black, resembling the sulfite black liquor used as a raw material in vanillin production. The monitoring wells that contained the black liquid are DM-2A, DM-2B, DM-5, DM-8, MW-B2, H6, H9, H10, and H11. The chemical quality of groundwater samples from these wells was highly variable. In some cases, the variability is believed to be due to the black liquid plume mixing with other groundwater releases and not because the black liquid itself contains significant levels of constituents of concern. This appears to be the case in wells MW-H10 and H11 which contained the black liquid and very high levels of toluene. In other wells which contained black liquid, none or very few hazardous substances were detected (e.g., DM-5, DM-8, and MW-H6).

If it is assumed that the black liquid is primarily composed of the sulfite liquor, then detections of priority pollutant or hazardous substance list constituents would not be expected. This is because the liquor consists mostly of organic acids and other dissolved humic material that are not identified by the analytical methods utilized in this investigation. However, if the black liquid is released after undergoing processing (such as solvent extraction), a large number of constituents could be present.

In general, samples of black liquid from wells MW-H10 and H11 were the only black liquid samples to contain levels of organic constituents that exceeded screening criteria. These

wells are addressed in Section 7.2. However, black liquid samples collected during the drilling of DM-4 and DM-5 in 1986 contained 470,000 and 330 ppb of toluene, respectively, (Dames & Moore 1986).

All of the black liquid samples contained elevated levels of chromium. With the exception of MW-H11 and MW-B2, all of the shallow wells containing black liquid exceeded the screening criterion for chromium and all of the exceedances were from wells that contained the black liquid. The concentrations of chromium measured in MW-H11 and MW-B2 were only slightly below the chromium screening criterion. The mean concentration of chromium in the eight shallow wells that contained the black liquid plume is 129 ppb. A relationship between chromium and the black liquor could not be determined based on available process information.

An indicator of the presence of the black liquid is the level of TOC within the sample. TOC was measured in all of the monitoring wells installed during this investigation. The results are summarized in Table 2 of Appendix F. TOC ranged from 113-318 mg/L (mean=222 mg/L) in the five wells which contained black liquid and were tested for TOC. The mean TOC concentration in the wells (excluding MW-B1B) which did not contain black liquid was 24 mg/L.

7.6.2 Remediation Assessment

The likelihood that remediation of the black liquid plume will be required by the agencies is considered moderate. The presence of chromium at elevated levels, the high TOC concentrations [and likely high biological oxygen demand (BOD)], and the obvious exceedance of secondary drinking water standards for color, indicates that the potential for remediation cannot be ruled out. Potential remediation technologies and cost estimates for remediation of the black liquid plume are presented in Section 8.0. Remediation of areas which contained black liquid and constituents that exceeded the screening criteria (e.g., MW-H10 and MW-H11) are discussed in Sections 7.2, 7.3, and 7.4.

The presence of the black liquid may also result in additional construction costs during site development because discharge of dewatering water containing the black liquid may be restricted. In 1987 Ecology issued a temporary permit for discharging dewatering water to Slip No. 6 during construction near the site. The permit specified a discharge limit of 50 mg/L for TOC which is well below the mean concentration of TOC within the black liquid plume (222 mg/L). If discharge limits cannot be met at the site, options include treating the water onsite or, if approved by Metro, discharging directly to the Metro Publicly Owned Treatment Works (POTW). Because dewatering flow rates and TOC concentrations in the dewatering water cannot

be determined at this time, an estimated cost for onsite treatment is not provided. Metro has provided a unit cost of \$3 per 1,000 gallons (Landau Associates 1991c) to discharge directly to the POTW, assuming Metro will accept the water. Using these unit costs, costs for discharging at various flow rates to the POTW are presented below. The costs assume that water is generated continuously at the rate shown for a 6-month period:

<u>Total Dewatering Flow Rate (GPM)</u>	<u>POTW Disposal Cost</u>
25	\$20,000
50	\$40,000
100	\$80,000
200	\$160,000

For capacity reasons, it is unlikely that Metro would accept flow rates higher than 100-200 gpm. Higher flow rates than those shown above could be generated during dewatering and therefore onsite treatment could be required.

The discharge permit also restricted the level of chromium in the water to not exceed the freshwater chronic criteria or background (Duwamish Waterway), whichever is greater. Freshwater chronic criteria for chromium is divided into hexavalent chromium (11 ppb) and trivalent chromium (117 ppb). As reported earlier, the mean concentration of chromium (Total) in the black liquid plume is 129 ppb. Chromium is usually in the reduced or trivalent state in groundwater, however, this will require laboratory verification. Background levels in the Duwamish Waterway are not known. Other constituents detected in the groundwater (e.g., copper, arsenic) could also impact the discharge of the dewatering water.

7.7 OFFSHORE PROPERTY

7.7.1 Marine Sediment Quality

Marine sediment core samples were collected at the locations shown on Figure 2-1, as discussed in Section 5.1. Sampling procedures are summarized in Appendix B. The sample designations indicate the depth intervals of samples selected and composited for chemical analysis.

Samples of marine sediment were chemically analyzed for volatile and semivolatile organic compounds, metals, PCBs, total solids, and TOC as specified in Landau Associates (1991a). Results of chemical analyses are summarized in Table 3 of Appendix F. Laboratory

data sheets are included in Appendix J, Volumes 2 and 3. Chemical results show that some metals were detected in all samples. PCBs and volatile and semivolatile organic compounds were detected in some samples. TOC results show that levels range from 0.1 percent to 3.9 percent. The shallower sediment samples (0.0-0.5 ft and 0.5-1.5 ft) generally contain higher concentrations of organic carbon and chemical constituents than deeper sediment samples (2.0-3.8 ft).

Marine sediment data have been evaluated using the criteria in the Washington State Department of Ecology Sediment Management Standards (SMS, WAC 173-204) and the criteria in the U.S. Army Corps of Engineers Puget Sound Dredge Disposal Analysis (PSDDA) program (U.S. Army Corps of Engineers et al. 1989). Table 6-3 provides a summary of criteria. This evaluation of marine sediment data has been accomplished to provide a general indication of sediment quality, evaluate any requirements for remedial action, and provide an indication of suitability for open-water disposal if dredging is considered.

Sediment Management Standards (WAC 173-204)

Normalization of laboratory concentrations of nonpolar organic chemicals using the concentration of TOC in sediments was accomplished to allow comparison with SMS criteria. Polar organics and metals do not require normalization. Table 4 of Appendix F presents normalized concentrations of nonpolar semivolatile organic compounds and PCBs in mg/kg organic carbon.

No volatile organic chemical criteria are included in the SMS; thus, no evaluation of detected volatile organic compounds are considered. No metals concentrations exceed SMS criteria; thus, no additional discussion of metals data is presented. Table 7-6 shows the samples that exceed SMS criteria.

PCBs were detected at sample Stations SD-J1, SD-J2, SD-J3, SD-J4, SD-J5, SD-J6, and SD-J7. Normalized PCB levels in Samples SD-J1-0.0-0.5, SD-J3-0.5-1.5, and SD-J5-0.0-0.5 exceed SMS Quality Standards, but not Minimum Cleanup Levels. Remedial action is not likely to be required based on PCBs.

Comparison with criteria shows that bis(2-ethylhexyl)phthalate from sample SD-J1-0.0-0.05 exceeds both SMS Quality Standards and Minimum Cleanup Levels. Small concentrations of bis(2-ethylhexyl)phthalate were reported in the laboratory blank sample; however, the concentration in Sample SD-J1-0.0-0.5 was high enough that the source does not appear to be related to laboratory contamination. This isolated detection suggests that the

concentration in this sample is anomalous. The SMS allow isolated detections to be averaged with detections in nearby sampling stations when comparing concentrations to SMS criteria. The mean concentration of bis(2-ethylhexyl)phthalate in Sample SD-J1-0.0-0.5 and in two nearby samples, Sample SD-J2-0.0-0.05 and SD-J3-0.0-0.5, also exceeds minimum cleanup levels due to the high concentration present in Station SD-J1. This exceedance could potentially trigger a finding of "potential concern" and a designation of the area in the vicinity of Station SD-J1 as a "cleanup site."

Discussion with agency personnel concerning the application of regulations to these results confirms that biologic testing to assess the effects of contaminants would normally be accomplished when results exceed Minimum Cleanup Levels (Landau Associates 1991b). It was agreed that the high concentration of a single chemical in only one of the eight surface samples may be anomalous and confirmation resampling was appropriate prior to conducting biological testing or a hazard assessment. A potential source of the bis(2-ethylhexyl)phthalate is plastic shavings that may have been incorporated into the sample when the plastic sample tubes were cut.

PSDDA Criteria

A comparison to PSDDA criteria was accomplished in order to provide a general indication of marine sediment quality and suitability for open-water disposal of sediments if dredging is considered. As shown in Table 7-7, comparison of results to PSDDA criteria shows that criteria for metals, PCBs, and semivolatile organics (both individual PAHs and total HPAHs) are exceeded at many near-surface sediment sample stations. This suggests that biological testing may be required to demonstrate suitability for open-water disposal. In cases where exceedances are limited to surface sediments, compositing allowed under PSDDA evaluation procedures might yield concentrations below screening levels, thus potentially eliminating a requirement for biological testing.

7.7.2 Seep Quality

Three seeps were sampled during low tide, shown on Figure 2-1. Seeps were not present at other locations along the offshore property during sampling. The chemical results of seep sampling are presented in Table 2 of Appendix F. Sampling procedures are discussed in Appendix B.

Volatile organics were not detected in any of the samples. The metals data were compared to the screening criteria developed for groundwater in Section 6.0 because, with the exception of chromium, the screening criteria for metals were based on aquatic life criteria, detection levels, or background levels. The screening criterion for chromium was set equal to the aquatic life criterion for trivalent chromium, 117 ppb. Constituents which exceeded the screening criteria included arsenic, copper, lead, and zinc. Exceedances of the screening criteria in seep samples are summarized in Table 7-8.

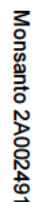
The sample from Seep 2 resembled the black liquid observed in Sector H wells. The TOC of this sample was measured at 323 ppm. The sample contained elevated levels of chromium (80 ppb), which is consistent with the levels of chromium found in the black liquid collected from onshore monitoring wells.

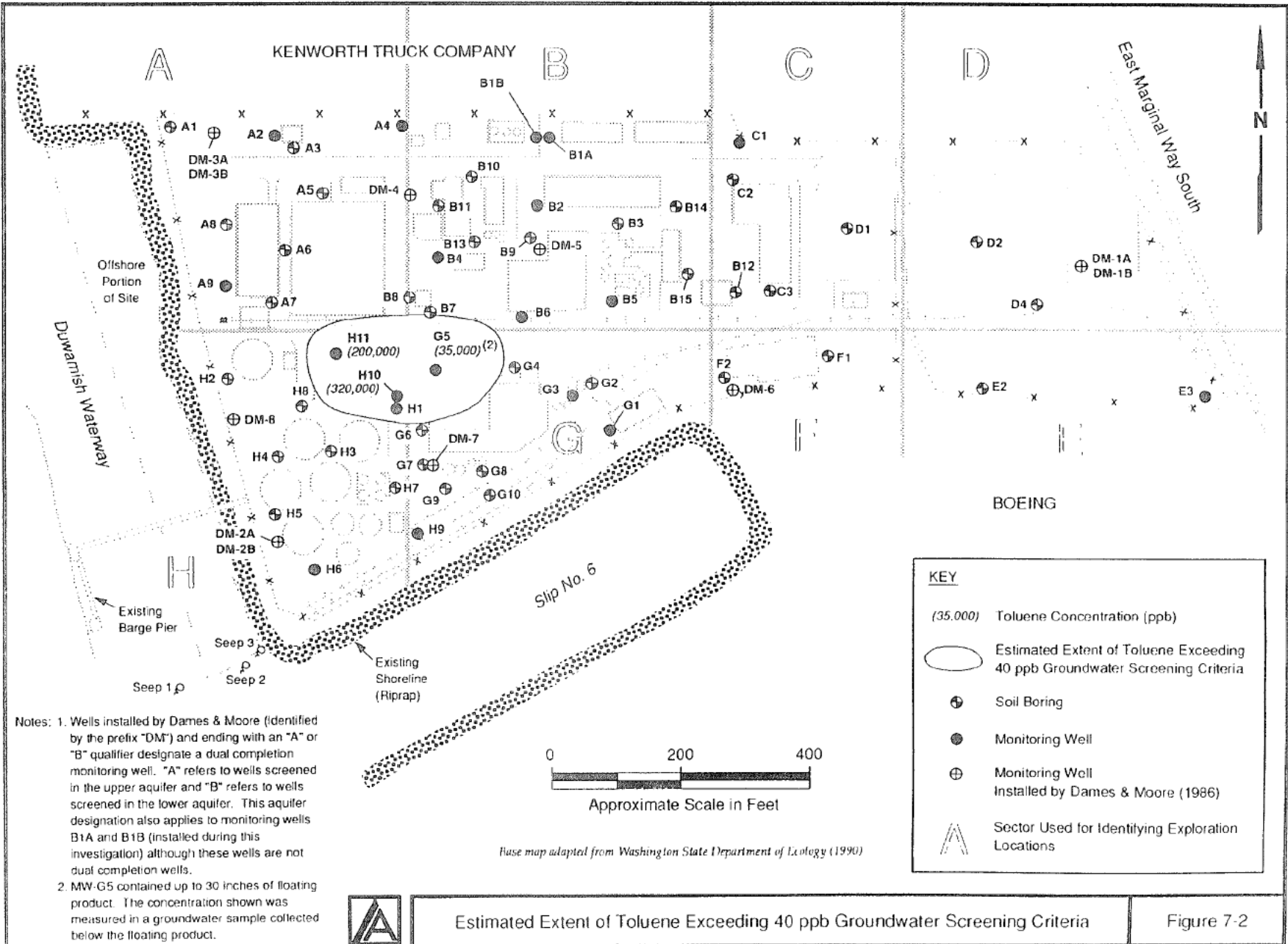
7.7.3 Remediation Assessment

The concentration of bis(2-ethylhexyl)phthalate in sediment Sample SD-J1-0.0-0.5 exceeds Ecology's SMS Minimum Cleanup Levels. This is the only chemical compound in Sample SD-J1-0.0-0.05, from underlying Sample SD-J1-2.3-3.8 or from any of the eight sample sites, which exceeds the Minimum Cleanup Levels. Although a remedial requirement cannot be ruled out, it is likely that additional sampling will show acceptable levels. If confirmation resampling shows acceptable levels, no hazard assessment or "potential concern" designation are likely. For this reason no sediment remediation cost estimate is presented. Sediment contaminant concentrations do exceed some PSDDA screening levels, suggesting that if dredging and open-water disposal of dredged material are contemplated, biological testing may be required to demonstrate suitability for open-water disposal.

The presence of copper and arsenic in the seep samples are evaluated along with the copper and arsenic detections in Sector H (Section 7.4.3) when assessing the need for remediation. Remediation of the other constituents that exceeded screening criteria is unlikely based on the following:

- Lead: slight exceedance of the criteria
- Zinc: only exceedance of the zinc screening criteria onsite.





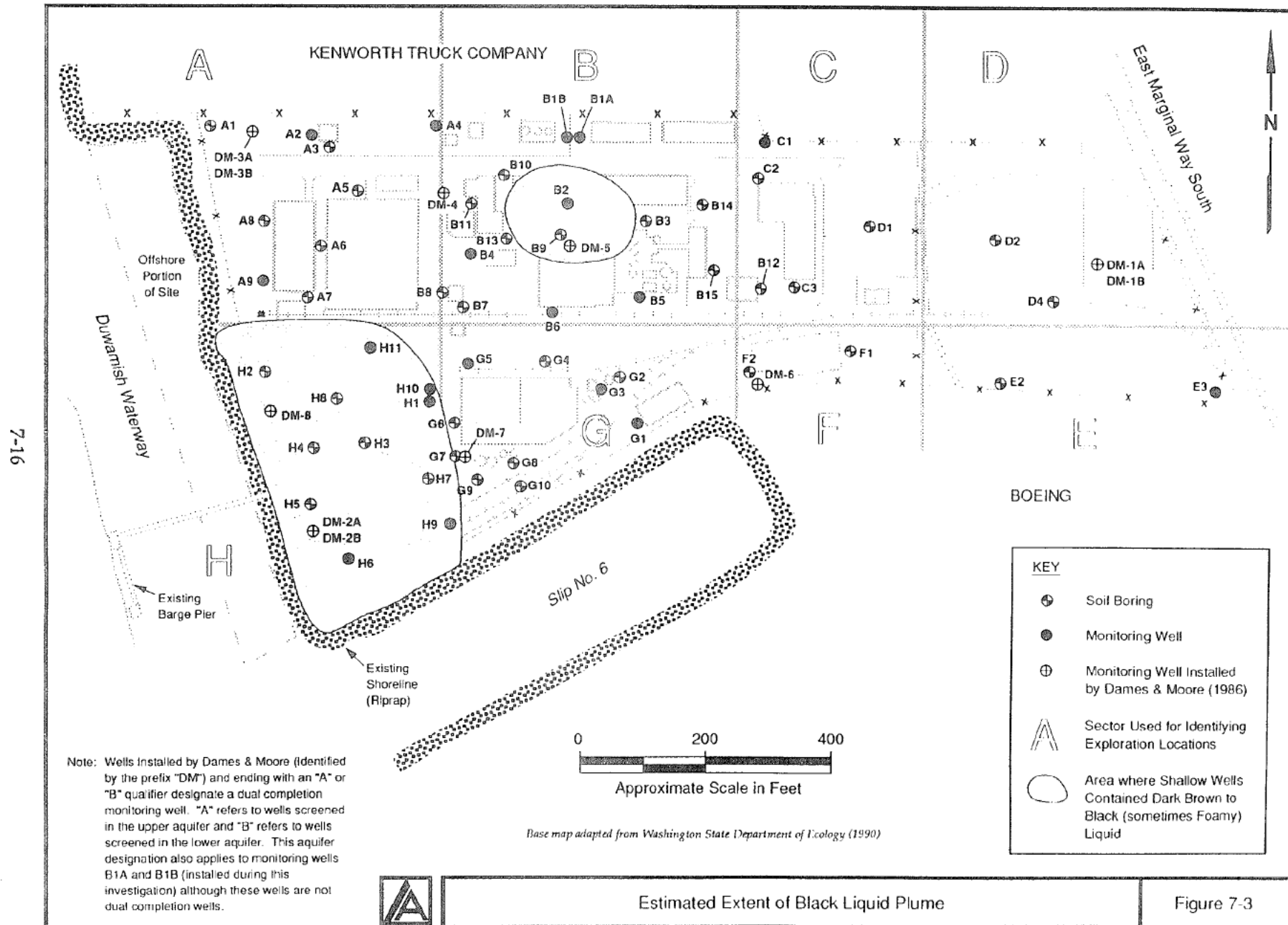


TABLE 7-1
GROUNDWATER FIELD PARAMETERS

Monitoring Well	Date Sampled	pH	Conductivity (μ S)	Temperature ($^{\circ}$ C)
MW-A2	July 23, 1991	6.55	1,053	14.7
MW-A4	July 23, 1991	6.11	430	18.6
MW-A9	July 23, 1991	5.76	367	16.2
MW-B1A	July 24, 1991	6.58	214	18.7
MW-B1B	July 25, 1991	7.58	334	15.8
MW-B2	July 25, 1991	6.36	1,057	16.4
MW-B4	July 22, 1991	7.59	2,140	20.5
MW-B5	July 24, 1991	6.59	855	14.9
MW-B6	July 25, 1991	6.54	1,853	17.4
MW-C1	July 24, 1991	6.38	480	15.3
MW-E3	July 24, 1991	5.93	366	13.9
MW-G1	July 22, 1991	6.38	659	17.7
MW-G3	July 22, 1991	6.79	628	18.1
MW-G5	July 24, 1991	6.30	1,114	16.7
MW-H1	July 25, 1991	7.56	2,410	22.1
MW-H6	July 23, 1991	6.97	4,690	20.3
MW-H9	July 23, 1991	7.10	2,320	16.5
MW-H10	July 23, 1991	6.62	1,006	36.3
MW-H11	July 23, 1991	6.34	1,742	16.5
DM-1A	June 28, 1991	6.07	293	15.3
DM-1B	June 28, 1991	8.44	843	17.1
DM-2A	June 27, 1991	7.69	7,530	18.8
DM-2B	June 28, 1991	8.88	2,840	17.4
DM-3A	June 27, 1991	6.49	827	14.4
DM-7B	June 27, 1991	8.46	1,619	13.8
DM-4	June 28, 1991	6.50	736	16.0
DM-5	June 27, 1991	6.81	4,580	17.7
DM-6	June 28, 1991	6.35	473	15.6
DM-7	June 28, 1991	6.52	1,027	21.7
DM-8	June 27, 1991	6.59	1,109	15.3

TABLE 7-2
MW-G5 AREA SCREENING CRITERIA EXCEEDANCES

Constituent	Soil		Groundwater	
	Screening Criteria Concentration (ppb)	Exceedance Location (and Concentration, ppb)	Screening Criteria Concentration (ppb)	Exceedance Location (and Concentration, ppb)
Toluene	40,000	G5-11.5 (2,900,000), G5-13.0 (5,400,000), H1-2.5 (28,000,000), H1-5.0 (4,800,000), H1-7.5 (11,000,000), H1-10.0 (210,000), H1-12.5 (11,000,000), H11-5.0 (210,000), H11-7.5 (2,700,000), H11-10.0 (1,900,000)	40	G5 (35,000), H10 (330,000), H11 (200,000)
Ethylbenzene	20,000	G5-11.5 (1,900,000)	DNE	
Pentachlorophenol	70	H1-2.5 (430), H1-7.5 (110M)	NA	
Acetone	80,000	H11-7.5 (120,000)	800	G5 (2,200)
Carcinogenic PAH	DNE		0.28	H10 (0.585)
Bis(2-Ethylhexyl)phthalate	625	G5-11.5 (1,300), G5-13.0 (3,000), H1-5.0 (6,300), H1-12.5 (1,300)	NA	
Arsenic	DNE		5	G5 (24), H10 (61J), H11 (40J)
Chromium	DNE		50	H10 (77)
Nickel	DNE		10	H10 (20)
Copper	DNE		7	H1 (36), H10 (96)
Lead	DNE		2	H10 (8)

DNE = Does Not Exceed screening criteria.

NA = Not Analyzed.

M = Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

J = Indicates an estimated value when result is less than specified detection limit.

TABLE 7-3
SECTORS A AND B SCREENING CRITERIA EXCEEDANCES

Constituent	Soil		Groundwater	
	Screening Criteria Concentration (ppb)	Exceedance Location (and Concentration, ppb)	Screening Criteria Concentration (ppb)	Exceedance Location (and Concentration, ppb)
Toluene	40,000	B11-7.5 (73,000J), B13-2.5 (5,400,000), B13-5.0 (250,000), B13-7.5 (45,000), B13-10.0 (330,000)	DNE	
Benzene	DNE		5	B5 (6.3)
Formaldehyde	NA		1.5	A9 (3.38J)
Carcinogenic PAH	DNE		0.28	B6 (0.358)
Pentachlorophenol	70	A5-5.0 (610), A5-2.5 (170 J), B7-5.0 (160 J)	NA	
Bis(2-Ethylhexyl)phthalate	625	B8-5.0 (1,200), B8-7.5 (1,000), B8-10.0 (770)	NA	
Arsenic	DNE		5	B5 (8), DM-3B (11), B6 (18), DM-5 (63), B2 (9), DM-3A (15), A2 (33J)
Chromium	DNE		50	DM-5 (385)
Copper	64	B2-2.5 (135), B6-5.0 (2,750), B13-2.5 (86), B13-5.0 (68), B13-10.0 (65)	7	B2 (9), B4 (12), B6 (10), DM-3B (19), DM-5 (31)
Nickel	32	B2-2.5 (42)	10	DM-5 (20)

DNE = Does Not Exceed screening criteria.

NA = Not Analyzed.

M = Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

J = Indicates an estimated value when result is less than specified detection limit.

TABLE 7-4

SECTOR H SCREENING CRITERIA EXCEEDANCES

Constituent	Soil		Groundwater	
	Screening Criteria Concentration (ppb)	Exceedance Location (and Concentration, ppb)	Screening Criteria Concentration (ppb)	Exceedance Location (and Concentration, ppb)
Arsenic	DNE		5	DM-2A (72), DM-8 (50), MW-H6 (25.2J), DM-2B (48)
Chromium	DNE		50	DM-2A (257), DM-8 (62), MW-H6 (94)
Copper	64	H5-2.5 (1,800), H5-5.0 (177)	7	DM-2A (44), DM-2B (73), DM-8 (29)
Nickel	32	H2-2.5 (41)	10	DM-2A (20)

DNE = Does Not Exceed screening criteria.

NA = Not Analyzed.

M = Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

J = Indicates an estimated value when result is less than specified detection limit.

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TABLE 7-5

SECTORS C, D, E, F, AND G SCREENING CRITERIA EXCEEDANCES

Constituent	Soil		Groundwater	
	Screening Criteria Concentration (ppb)	Exceedance Location (and Concentration, ppb)	Screening Criteria Concentration (ppb)	Exceedance Location (and Concentration, ppb)
Pentachlorophenol	70	G7-2.5 (350), G7-5.0 (150M), G8-2.5 (110M)	NA	
Arsenic	DNE		5	C1 (7), DM-1B (21.4), DM-6 (12.6), DM-7 (21), G1 (6), H9 (70J)
Chromium	DNE		50	H9 (69)
Cadmium	DNE		2	C1 (3)
Lead	DNE		2	H9 (4)
Copper	DNE		7	DM-1A (17), DM-1B (9), DM-6 (27)

DNE = Does Not Exceed screening criteria.

NA = Not Analyzed.

M = Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

J = Indicates an estimated value when result is less than specified detection limit.

TABLE 7-6

MARINE SEDIMENT CHEMICAL RESULTS EXCEEDING WAC 173-204 CRITERIA

Compound	Quality Standard (mg/kg as Organic Carbon)	Minimum Cleanup Level (mg/kg as Organic Carbon)	Sample Exceeding Criteria
Total PCB	12	65	SD-J1-0.0-0.5 SD-J3-0.5-1.5 SD-J5-0.0-0.5
bis(2-Ethylhexyl)phthalate	47	78	SD-J1-0.0-0.05

TABLE 7-7

MARINE SEDIMENT CHEMICAL RESULTS EXCEEDING PSDDA CRITERIA

Constituent	Screening Level	Maximum Level	Sample Exceeding Criteria
Copper (mg/kg)	81	81	SD-J1-0.0-0.5 SD-J4-0.0-0.5
Mercury (mg/kg)	0.21	2.1	SD-J1-0.0-0.5 SD-J3-0.5-1.5 SD-J4-0.5-1.5 SD-J6-2.4-3.4 SD-J7-2.5-3.5
Zinc (mg/kg)	160	1,600	SD-J1-0.0-0.5
Phenol	120	1,200	SD-J3-0.5-1.5
4-Methylphenol (µg/kg)	120	1,200	SD-J1-0.0-0.5
Benzoic Acid (µg/kg)	216	690	SD-J3-0.5-1.5 SD-J6-2.4-3.4 SD-J7-0.0-0.5
Phenanthrene (µg/kg)	320	3,200	SD-J6-0.0-0.5
Fluoranthene (µg/kg)	630	6,300	SD-J1-0.0-0.5 SD-J6-0.0-0.5
Pyrene (µg/kg)	430	7,300	SD-J1-0.0-0.5 SD-J3-DUP(10) SD-J3-0.0-0.5 SD-J4-0.0-0.5 SD-J6-0.0-0.5
Chrysene (µg/kg)	670	6,700	SD-J6-0.0-0.5
Benzo(a)anthracene (µg/kg)	450	4,500	SD-J6-0.0-0.5
Benzo(a)fluoranthene (µg/kg)	800	8,000	SD-J1-0.0-0.5 SD-J6-0.0-0.5
Indeno(1,2,3-cd)Pyrene (µg/kg)	69	5,200	SD-J1-0.0-0.5 SD-J2-0.0-0.5 SD-J3-0.0-0.5 SD-J3-DUP(10) SD-J4-0.0-0.5 SD-J5-0.0-0.5 SD-J6-0.0-0.5
Total HPAH (µg/kg)	1,800	51,000	SD-J1-0.0-0.5 SD-J2-0.0-0.5 SD-J3-0.0-0.5 SD-J3-DUP(10) SD-J4-0.0-0.5 SD-J6-0.0-0.5

TABLE 7-7

MARINE SEDIMENT CHEMICAL RESULTS EXCEEDING PSDDA CRITERIA

Constituent	Screening Level	Maximum Level	Sample Exceeding Criteria
bis(2-ethylhexyl)phthalate (µg/kg)	3,100	--	SD-J1-0.0-0.5
Total PCBs (µg/kg)	130	2,500	SD-J1-0.0-0.5 SD-J2-0.0-0.5 SD-J3-0.0-0.5 SD-J3-0.5-1.5 SD-J4-1.5-2.5 SD-J5-0.0-0.5

TABLE 7-8

SEEP SAMPLES SCREENING CRITERIA EXCEEDANCES

Constituent	Screening Criteria Concentration (ppb)	Exceedance Location (and concentration, ppb)
Arsenic	5	Seep 2 (27)
Copper	7	Seep 1 (160), Seep 2 (10)
Lead	2	Seep 1 (12), Seep 2 (8)
Zinc	59	Seep 1 (310)

8.0 ESTIMATED REMEDIATION COSTS

This section presents estimated costs to remediate the four areas identified in Section 7.0 where remediation was determined to be moderately likely or likely. These areas are:

- MW-G5 Plume Area - Soil
- MW-G5 Plume Area - Groundwater
- Sector B - Soil
- Black Liquid Plume - Groundwater.

The costs presented in this report are based on numerous assumptions and unresolved issues and should be considered preliminary estimates only. Actual cleanup costs in each area could vary substantially depending on the degree of refinement of several key issues. These include:

- The costs presented are based on a limited knowledge of the extent of constituents of concern and hydrogeologic characteristics at the site. Additional site investigations and predesign testing will be necessary prior to designing an actual remedial action.
- Investigations accomplished beneath areas currently occupied by buildings or other structures could yield additional areas where remediation is likely.
- The length of time required to operate the remediation technologies in order to achieve the desired reduction in constituent levels is unknown.
- The selection of the actual technology to be used may not include those discussed here.
- The unit costs obtained for the various cleanup technologies are, in general, based on Landau Associates' experience with other cleanup actions and contacts with industry representatives. The unit costs are not specific to the site.
- Some of the technologies rely on discharging groundwater to the POTW. Authorization for these discharges has not been discussed with or approved by Metro. If Metro does not accept the discharge, the next most likely alternative is to discharge to the waterway. This would likely require obtaining an NPDES permit which could take 2 years or more.

In addition, the decisions as to whether or not remediation is required in a given area have not been discussed with, or approved by, Ecology. Such discussions could yield higher or lower screening criteria and therefore add or delete areas requiring remediation (e.g., the black

liquid plume). Adding or deleting areas could also result in a substantial change to the total site remediation cost obtained by adding the costs of remediating the individual areas presented in this section.

Assumptions and unit costs used in developing the cost estimates are presented in Appendix I. Remediation of each of the four areas are discussed separately below.

8.1 MW-G5 PLUME AREA - SOIL

The estimated extent of soil within the MW-G5 plume area which will likely require remediation is shown on Figure 7-1. The depth of soil to be remediated was estimated at 15 ft. Two remedial alternatives were evaluated for the soil in the MW-G5 Plume Area: 1) Soil vacuum extraction with offgas treatment by thermal oxidation, and 2) *In situ* bioremediation using soil flushing with nutrient and oxygen enriched water. Several other alternatives exist; however, the two alternatives evaluated represent feasible and potentially cost-effective technologies for site conditions in this area. Cleanup goals for toluene were assumed to be equivalent to the screening criteria presented in Section 6.0.

Vacuum extraction utilizes extraction wells connected to a vacuum blower which draws gases from the soil to the surface for subsequent treatment and discharge. The toluene found in the soil is volatile and consequently amenable to removal by vacuum extraction. The system preliminarily identified for this area consists of six extraction wells with a depth of 15 ft. A total air flow rate of 500 scfm was assumed with one vacuum blower. Based on the concentrations of toluene in the soil, offgas treatment would be required. Offgas treatment by thermal oxidation was selected based on cost-effectiveness over alternative treatment processes. A 2-year time frame was estimated for system operation.

In situ bioremediation using soil flushing would be implemented in conjunction with groundwater bioremediation, both of which are applicable to the toluene found in the soil. This technology utilizes extracted groundwater which is first treated in a bioreactor and then dosed with nutrients and an oxygen source. This water would then be infiltrated into the soil through shallow trenches. The infiltrated water supplies both nutrients and oxygen to the soil to stimulate biodegradation, as well as flushing contaminants from the soil to the groundwater for subsequent extraction and treatment. Bioremediation of the soil is expected to take on the order of 2-5 years to achieve remediation goals. A 5-year time frame was used for cost estimating purposes. A summary of costs is presented in Section 8.5 for combined soil and groundwater remediation for the MW-G5 Plume Area.

8.2 MW-G5 PLUME AREA - GROUNDWATER

The extent of the MW-G5 toluene plume requiring remediation is shown on Figure 7-2. Two remedial alternatives were evaluated for groundwater in the MW-G5 Plume Area: 1) Groundwater extraction with treatment by air stripping, offgas treatment by thermal oxidation, and offsite discharge of treated groundwater, and 2) groundwater extraction and a combination of aboveground biological treatment and *in situ* bioremediation. Both technologies are considered feasible and potentially cost-effective. A separate floating product skimming system is included in both alternatives to recover LNAPL. Cleanup goals were assumed to be equivalent to the screening criteria presented in Section 6.0.

The two groundwater treatment alternatives were assumed to be integrated with the two soil remediation alternatives presented above. The thermal oxidation unit would be used for offgas treatment for both vacuum extraction and air stripping. The bioremediation alternative would be operated as a closed loop with extraction and subsequent infiltration of a portion of the groundwater to the soil.

Both alternatives were assumed to utilize four groundwater extraction wells with a depth of 45 ft, and a total groundwater extraction rate of 80 gpm. The assumed flow rate of 80 gpm is based on a groundwater extraction analysis presented in Appendix H which utilized an analytical groundwater computer model to estimate the flow rate needed to capture the plume. The analysis did not consider reinjection of the treated water for the *in situ* bioremediation alternative. The results indicated a likely range to be 30 to 80 gpm. Due to the level of uncertainty in the analysis and the fact that reinjection would increase the total flow rate, the high end of the calculated flow range was assumed for costing purposes. The 80 gpm flow rate was also used for cost estimating of the groundwater extraction and air stripping alternative for consistency.

For the alternative utilizing air stripping, a conventional packed tower was assumed, with offgas treatment by thermal oxidation. Offgas treatment from the air stripper is required based on the concentrations of toluene in the groundwater. Treated water was assumed to be discharged to the Metro POTW. Discharge to the POTW was selected due to the uncertainty of obtaining an NPDES direct discharge permit or onsite reinjection. Some uncertainty exists as well for obtaining a permit to discharge to the POTW. A 5-year operating time frame was assumed for cost estimating purposes.

The bioremediation system was assumed to include both aboveground treatment using a bioreactor, as well as *in situ* treatment utilizing nutrient and oxygen enriched water to enhance

biodegradation. Extracted groundwater would first be treated in the bioreactor, effecting treatment of toluene and amenable TOC, with some limited metals removal. The treated water would then be dosed with nutrients and an oxygen source and infiltrated to the soil. An estimated 50 percent of the treated water was assumed to be discharged to the Metro POTW prior to nutrient addition to enable adequate capture of injected water. Subsurface biodegradation would then be stimulated by the nutrient enriched water. Sludge generated by the bioreactor was presumed to be disposed at a secure landfill. A 5-year operating time frame was assumed for cost estimating purposes.

Uncertainty exists as to regulatory approval of infiltration due to the low levels of metals existing in the groundwater. In addition, fugitive volatile emissions from a bioreactor may require treatment if emission levels are significant. If these two issues were to become significant, the cost of bioremediation could increase significantly.

8.3 SECTOR B SOIL

The estimated extent of soil within the Sector B area which requires remediation is shown on Figure 7-1. The depth of soil to be remediated was estimated at 15 ft. Two remedial alternatives, soil vacuum extraction with offgas treatment by thermal oxidation and excavation and offsite disposal, were evaluated for this soil. Bioremediation was not evaluated for this area because the groundwater in this area does not appear to require remediation, and consequently it is inappropriate to risk mobilization of contaminants to the groundwater through water flushing. Cleanup goals were assumed to be equivalent to the screening criteria presented in Section 6.0.

The vacuum extraction system utilized for Sector B soils would be very similar to that used for the MW-G5 Plume Area soils. If remediation of both areas was done concurrently, the potential would exist for using some common equipment for both areas (such as the thermal oxidation unit). The system preliminarily identified for this area consists of five extraction wells with a depth of 10 ft. A total air flow rate of 500 scfm was assumed, with one vacuum blower. Based on the concentrations of toluene in the soil, offgas treatment by thermal oxidation was selected. A 2-year time frame was estimated for system operation.

Soil excavation and offsite disposal was evaluated as an alternative to allow unencumbered use of this area as quickly as possible. Excavation would proceed to the water table, and onsite solidification would be done as required for free liquid control. Offsite disposal

was presumed to be at the Arlington, Oregon TSD facility. Backfilling with common pit run gravel and light compaction was included.

8.4 BLACK LIQUID PLUME

The extent of the Black Liquid Plume Area which potentially requires remediation is shown on Figure 7-3. One remedial alternative, groundwater extraction and discharge to the Metro POTW, was evaluated for this area. No treatment is included for this groundwater because the primary constituent of concern is TOC, which is effectively treated at the POTW and consequently has no discharge limitation. The level of chromium present in the black liquid plume is below current Metro discharge limitations (Metro 1990), and is not anticipated to require treatment.

Groundwater extraction for this area was assumed to utilize 20 wells, each producing approximately 20 gpm. Due to the potential for limitations on discharge rate to the sanitary sewer, it was assumed that only a portion of the wells would operate at one time. A total discharge rate of 100 gpm was assumed. A 5-year operating time frame was assumed for cost estimating purposes. Other technologies could be employed to reduce the duration of remediation (e.g., placement of sheet piles along the Duwamish River shoreline to reduce surface water intrusion).

A number of uncertainties exist in analysis of this alternative, including flow rate limits for sewer discharge, treatment requirements, duration of remediation, and cleanup goals for the groundwater. Each area of uncertainty could potentially have a significant effect on the cost of remediation of this area.

8.5 COST SUMMARY

Preliminary cost estimates are presented in this section for the remediation alternatives identified above. These cost estimates are very preliminary, for the reasons given in the introduction to Section 8.0. In addition, if remedial actions were to be simultaneously undertaken for all media identified, economies of scale could be realized.

Cost estimates were developed for two remedial alternatives for MW-G5 soil and groundwater and Sector B soil, and one remedial alternative for the black liquid plume. Capital, annual operation and maintenance, and present worth cost estimates were prepared. The cost estimates are summarized below:

Alternative	Capital Cost	Annual Operation and Maintenance Cost	Present Worth of Capital and Operation and Maintenance Cost
<u>MW-G5 Plume Area</u>			
Alternative 1 - Soil Vacuum Extraction, Groundwater Extraction with Air Stripping	\$1,177,700	\$ 376,300	\$2,601,500
Alternative 2 - Soil and Groundwater Bioremediation	\$1,300,600	\$ 581,100	\$3,816,000
<u>Sector B Soil</u>			
Vacuum Extraction	\$ 445,500	\$ 102,700	\$ 636,500
Soil Excavation with Offsite Disposal	\$6,123,000	NA	\$6,123,000
<u>Black Liquid Plume</u>			
Groundwater Extraction with Discharge to POTW	\$ 770,900	\$ 356,000	\$2,351,000

NA = Not Applicable.

Cost estimate spread sheets are presented in Appendix I. These spread sheets identify the assumptions, unit costs, and cost factors used in preparing these estimates. Significant uncertainty exists within many of the assumptions made for these estimates. Spread sheet calculation of some costs result in costs presented to the dollar, however no inference to that level of accuracy is intended.

9.0 INVESTIGATION LIMITATIONS

Limited information was obtained in the following three areas of the investigation:

- As a result of a miscommunication between the laboratory and field planning personnel, analysis of water samples for semivolatile organics, with the exception of PAH, was not accomplished. Therefore, the levels of phenolic compounds, including pentachlorophenol and methyl phenols, and phthalates in site groundwater could not be assessed. These constituents were detected in site soil.
- Areas beneath buildings and other site structures were not investigated because of access limitations.
- Evaluation of marine sediment quality was limited to approximately the upper 4 ft of sediment because coring equipment could not be advanced through material below this level.

10.0 USE OF REPORT

This report was prepared for The Boeing Company, Seattle, Washington. The findings and opinions presented herein are based on observations and data gathered at specific locations and times; therefore, additional investigation may result in different findings, opinions, and conclusions. Landau Associates, Inc. conducted this environmental site assessment using currently accepted methods for performing such investigations in the Seattle, Washington area; no other representation, express or implied, is included or intended in this report.

If you have any questions or require clarification on the contents of this report, please contact us.



LANDAU ASSOCIATES, INC.

By:

A handwritten signature in cursive script that reads "Jerry Ninteman".

Jerry R. Ninteman, P.E.
Project Manager

JRN/sms
No. 25-63.40

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APPENDIX A

Onshore Field Investigation Procedures

APPENDIX A

ONSHORE FIELD INVESTIGATION PROCEDURES

This section presents the exploration and sampling procedures used by Landau Associates, Inc. (Landau Associates) during the onshore investigation of the Rhone-Poulenc property. Soil samples obtained during the investigation were classified in general accordance with the Soil Classification System, as shown on Figure C-1. Drilling, sampling, and well installation were observed at each location by an experienced Landau Associates geologist or engineer. Soil boring logs and monitoring well installation details are presented in Appendix C.

SOIL BORINGS

A total of 37 soil borings 9-16.5 ft deep, were drilled on the Rhone-Poulenc property during our investigation. The soil borings were drilled using a truck-mounted auger drilling rig with a 3-inch solid stem auger (except for Boring BN-H3, which was drilled using a hand auger because the location was not accessible to the drill rig). After the auger had reached the top of the desired sampling interval and had been pulled from the borehole, the depth was measured to determine if the borehole had caved. Significant cave-in was not observed in any of the borings. Soil samples were collected by driving a 2.42-inch ID, 18-inch split-spoon sampler with a 300-lb hammer (30-inch drop) into the undisturbed soil. Samples were collected at approximately 2.5-ft intervals. Immediately upon opening the sampler, the contents of the sampler were screened with a TIP photoionization detector and a sample was collected along the length of the spoon for possible analysis of volatile organics. The shoe portion of the sampler and the remaining contents of the sampler were then homogenized in a stainless steel bowl and placed in sample containers for other analyses. The sealed and labeled containers were stored in a cooler with ice and then delivered to the laboratory at the end of each day. Chain-of-custody records were maintained for each sample collected and included with each shipment of samples to the laboratory.

After drilling and sampling were completed at each boring, the borehole was filled with bentonite chips to approximately 1 to 2 ft below ground surface. The upper 1 to 2 ft was then filled with concrete. The augers and other down-hole equipment were taken to a designated decontamination area and steam cleaned thoroughly prior to the start of the next boring. The decontamination area was located east of BN-F1 and included a rack with sump and a "Baker"

Tank. Between the collection of each sample, the soil sampler, stainless steel bowls, and spoons were cleaned at the drilling location by: 1) scrubbing withalconox and tap water, 2) rinsing with tap water, and 3) rinsing with distilled water. Decontamination water was transported to the decontamination area and pumped into the Baker Tank. Drill cuttings were placed in 5-gal plastic containers and taken to the decontamination area. Disposable field clothing was taken to the decontamination area and placed in 55-gal drums.

Boring BN-H3 was completed with a 3-inch OD hand auger because the location was not accessible to the drill rig. Samples were collected directly from the auger head.

MONITORING WELL BORINGS AND WELL INSTALLATION

A total of 18 monitoring wells (18.5-62.0 ft) were installed in the upper aquifer and 1 well (98.1 ft) was installed in the lower aquifer. The decontamination procedures were the same as described above. The sampling varied, as described below.

Upper Aquifer Wells

The upper aquifer monitoring wells were drilled using a truck-mounted auger drilling rig with 4.25-inch ID hollow-stem auger. Samples were collected by driving a 2.4-inch ID, 18-inch split-spoon sampler with a 140-lb hammer (30-inch drop). MW-H1 was sampled with a 2.0-inch OD, 24-inch split-spoon sampler from 31.5-62.0 ft. Samples were taken approximately every 2.5 ft from ground surface to 10 ft, every 5 ft from 10 to 20 ft, and every 10 ft thereafter. Heaving sand was encountered while drilling below the groundwater surface. With the exception of wells MW-B4 and MW-H1 which were drilled to 54 and 62 ft, respectively, water was not added to the inside of the auger to control the heave because of the potential for the added water to affect the groundwater sample results. Due to the project schedule, wells were sampled within 1 to 2 weeks after installation; therefore, an effort was made to minimize the practice of adding water to control heave.

Lower Aquifer Well

One monitoring well (MW-B1B) was drilled into the lower aquifer. As with the existing Dames & Moore wells, it is distinguished from the other wells by having a "B" qualifier at the end of the well number. This well was drilled with a truck-mounted cable tool drilling rig. To minimize potential carry-down of constituents from the upper aquifer to the lower aquifer during drilling, the following procedures were followed during the drilling of MW-B1B. First,

an 8-inch temporary steel casing was drilled to 67 ft below ground surface, which is approximately 5.5 ft below the top of the aquitard. Next, Pure Gold® bentonite grout slurry was pumped into the 8-inch casing until approximately 5 ft of slurry was in the bottom of the casing. Following this, a 6-inch temporary steel casing was lowered inside the 8-inch casing to 67 ft and then driven an additional 5 ft. The bentonite grout slurry and some soil were then bailed out of the 6-inch casing and drilling resumed to the total depth of the well.

Samples were collected by driving a 2.42-inch ID, 18-inch split-spoon sampler with a 300-lb hammer (24-inch drop). Six samples were taken from 30 to 98.1 ft. Grab samples for soil classification purposes were taken approximately every 5-10 ft.

MONITORING WELL CONSTRUCTION

Monitoring wells were constructed in general accordance with WAC 173-160. Well screens ranged from 5 to 10 ft in length, (typically 10 ft) and were installed with the top of the screen above the top of the zone of saturation (at the time of drilling). When heaving conditions prevented the installation of the full 10-ft well screen, a portion of the screen was removed. For these wells, an end cap (slip type) was then secured with stainless steel screws, rather than the standard threaded end cap. Prior to installation, well casing, screen, and centralizers were inspected for damage and steam cleaned.

Well casings consisted of flush-threaded PVC blank casing and screen. The well casing was installed to the target depth through the hollow-stem auger, or in the case of MW-B1B, through the 6-inch steel casing. A filter pack of pre-sized, prewashed No. 10-20 Colorado Silica Sand was installed around the well screen, extending from the bottom of the borehole to approximately 1.7-5.8 ft above the screen. The filter pack was installed by carefully pouring sand down the annulus between the well casing and the hollow-stem auger (or 6-inch casing) as the auger (or casing) was slowly withdrawn. During the filter pack placement, the distribution and depth of the filter pack was monitored with a weighted tape.

With the exception of the three deeper wells, MW-B1B, MW-B4, and MW-H1, bentonite chips were placed above the filter pack to within several feet of the surface to provide a near-surface borehole seal. Bentonite pellets were used with the bentonite chips in MW-B5. For the three deeper wells (MW-B1B, MW-B4, and MW-H1), a 0.6 to 2 ft layer of relatively fine sand (Colorado 20-40 Silica Sand) was placed above the 10-20 sand pack followed by Pure Gold® grout slurry.

In some wells a near-surface layer of concrete was placed above the bentonite grout seal. A layer of pea gravel was then placed immediately above this concrete layer, on the bentonite seal, to provide drainage and act as a leveling coarse for the flush-mounted monuments. A locking waterproof seal was installed onto the PVC well casing, and a heavy duty (H-20 rated), cast-iron protective monument was set in a concrete surface seal around each well. Well construction details are provided in Appendix C.

MONITORING WELL DEVELOPMENT

Monitoring well development was accomplished after the wells were allowed to equilibrate for a minimum of 24 hours. Wells were developed to remove sediment (and, in the case of MW-B4 and MW-H1, water introduced during drilling) and to establish hydraulic continuity between the filter pack and the formation. Development was accomplished by overpumping the wells with a centrifugal or hand-operated positive displacement pump until each well was visibly free of sediment and the turbidity of the discharge water was low. The polyethylene tubing that was used to develop the wells was left in the well for use during groundwater sampling. Development water was collected and transferred to the Baker Tank.

WATER LEVEL MEASUREMENTS

Following well installation and development, water levels were measured during low and high tide to correlate groundwater elevations with tidal fluctuations in the Duwamish Waterway and Slip No. 6. Depth to water was measured with a water level indicator between 11:24 a.m. and 1:00 p.m. on July 25, 1991 to measure low tide influence (-7.08 ft, NGVD, at 11:01 a.m.), and between 5:05 p.m. and 6:50 p.m. on August 7, 1991 to measure high tide influence (+5.32 ft, NGVD, at 4:52 p.m.). Groundwater elevation data and contour maps are presented in Section 5.0.

GROUNDWATER SAMPLING

The existing Dames & Moore wells were sampled on June 27 to June 28, 1991 and the Landau Associates wells on July 22 to July 25, 1991. Prior to sampling, the water level in each well was measured to determine the volume of water within the casing. The water level recording probe was inspected for the visual presence of free product and free product odors.

Free product was detected in only one well, MW-G5. The thickness of the free product in the well was later estimated by using a steel tape and water finding paste and a clear bailer

equipped with a bottom check valve. The free product removed from the well was poured into a sample container and submitted to the laboratory for analysis.

Prior to sample collection, the wells were purged of at least three casing volumes of water with a centrifugal pump or a hand-operated positive displacement pump, both using dedicated polyethylene tubing. After each casing volume was removed, an aliquot of the purge water was tested in the field for pH, specific conductance, and temperature. If the results of the samples collected after the second and third casing volumes were within 10 percent of each other, the well was then sampled. If not, the well was purged until two consecutive casing volumes were within 10 percent.

Groundwater samples were collected in all wells with a disposable polyethylene bailer equipped with a bottom check valve, except MW-H1, which was sampled with a hand-operated positive displacement pump and MW-B2 which was sampled with a stainless steel bailer. Samples collected for the analysis of metals were filtered in the field through a 0.45 μm disposable filter.

SURVEY

The elevations of the soil borings and the monitoring wells were surveyed by Horton Dennis & Associates on July 25, 1991. All elevations were obtained via closed loop differential leveling with no closure greater than 0.02 ft. Elevations are referenced to National Geodetic Vertical Datum of 1929 (NGVD). Elevations are reported in Table 5-1 and in Appendix E.

APPENDIX B

Offshore Field Investigation Procedures

APPENDIX B

OFFSHORE FIELD INVESTIGATION PROCEDURES

INTRODUCTION

Landau Associates, Inc. (Landau Associates) conducted the offshore (shorelands) portion of the fieldwork for this project between July 9 and July 12, 1991. Sea Surveyor, Inc. of Benicia, California, under subcontract to Landau Associates provided a vibratory coring system (vibracorer). Marine Services Unlimited, Inc. of Seattle, Washington provided a 60-ft long, 22-ft wide, self-powered barge, also under subcontract to Landau Associates. Analytical Resources, Inc. of Seattle, Washington performed chemical analyses on the sediment samples collected during this study.

The field exploration program included the completion of seven sediment vibracores and eight surface grab samples. The locations of the cores and grab samples are shown on Figure 2-1.

VIBRACORES

The vibracorer is an air-powered sediment sampling system featuring a pneumatic impacting bin vibrator which drives a steel core containing a cellulose acetate buterate (CAB) liner into the sediment.

On July 9, 1991, Sea Surveyor and Landau Associates personnel attempted to collect vibracores from the beach using the vibracorer and semirigid support frame called a "Genie Lift." The Genie Lift, which is essentially a hand-operated forklift, supports the vibracorer in an upright position and allows it to penetrate into the sediment as the vibratory head is lowered. However, the combined weight of the vibracorer and Genie Lift made it difficult to move the equipment along the beach in soft sediments; therefore, its use was discontinued.

On July 10, 1991, Sea Surveyor and Landau Associates personnel mounted the vibracorer on a barge owned and operated by Marine Services Unlimited and collected seven sediment cores (PV-SD-J1 through PV-SD-J4, PV-SD-J6, PV-SD-J7, and PV-SD-J9) to depths of 3-6 ft below mudline. Sediment cores were not collected from station locations PV-SD-J5 and PV-SD-J8 because of near-surface refusal caused by either coarse-grained sediment (sands and gravels) or buried debris.

After collection, each sediment core (in a CAB liner) was capped at both ends; marked to denote the station identification, depth of penetration, bottom and top, and date and time

sampled; and then transported to shore for logging, field screening, and chemical sample collection. Once at the onshore processing area, the cores were manually extruded onto an aluminum sample tray and split lengthwise down the middle using a precleaned stainless steel knife. Immediately, subsamples were collected from the desired depths and placed in laboratory cleaned 4-oz glass jars with teflon-lined screw caps for analysis of volatile organic compounds. The sediment cores were then physically described in general accordance with Puget Sound Estuary Procedure (PSEP) protocols (PSEP 1986) (the exploration logs are presented in Appendix D). For the remaining analyses, subsamples were mixed to visible uniformity in precleaned stainless steel bowls and then placed into specially cleaned containers provided by the laboratory. All sample bottles were stored under refrigeration (at approximately 4°C) until delivered to the laboratory.

The residual sediment from each core was placed in 5-gal buckets and appropriately sealed and labeled to include the sampling station and date sealed.

SURFACE GRAB SAMPLES

On July 11, 1991, sediment surface samples (sediment surface to a depth of 6 inches) were collected from eight station locations (PV-SD-J1 through PV-SD-J7 and PV-SD-J9) using a hand-inserted CAB core tube during low tide. At each station, three replicate surface cores were collected and placed into a stainless steel bowl for compositing. Samples for analysis of volatile organic compounds were taken directly from each replicate core prior to homogenization and placed into laboratory supplied 2-oz glass jars using a stainless steel spoon. For the remaining analyses, the composited replicate samples were mixed to visible uniformity in a precleaned stainless steel bowl, then a portion of the composited sample was placed into specially cleaned containers provided by the laboratory. All sample bottles were stored under refrigeration (at approximately 4°C) until delivered to the laboratory.

The residual sediment from each surface sample was placed in 5-gal buckets and appropriately sealed and labeled to include the sampling station and date sealed.

SEDIMENT DESCRIPTIONS

Sediment cores were visually classified in the field in general accordance with PSEP protocols (PSEP 1986a,b). The following information was recorded on the field log sheet:

- Date, time, and name of person logging sample

- Station location (from known points along the shore and existing pier)
- Depth of water at location
- Sediment sample depth
- Gross physical characterization in general accordance with the visual-manual description procedure (Method ASTM D-2488), including:
 - Sample recovery
 - Grain size distribution
 - Density/consistency
 - Plasticity
 - Color
 - Moisture content
 - Biological structures (e.g., shells, tubes, macrophytes, bioturbation)
 - Presence of debris (e.g., wood chips, wood fibers, human artifacts)
 - Presence of oily sheen
 - Odor (e.g., hydrogen sulfide).

SEEP SAMPLING

Three seep samples were collected from the intertidal zone. Samples were obtained by holding sample bottles under flowing water at each seep location. At Seep 2, the larger bottles (metals, semivolatiles, formaldehyde) could not be fully immersed; therefore, the samples at Seep 2 were collected with a peristaltic pump. Polyethylene and tygon tubing were used with the peristaltic pump. Both the gloves and the tubing were changed prior to collecting samples at each location.

DECONTAMINATION PROCEDURES

Sampling and testing equipment was routinely decontaminated in the field prior to use and between each sampling event and/or sample collected. The CAB core tubes, core retainers/catchers, stainless steel bowls and spoons, aluminum trays, and sediment extruder were washed with a detergent solution (Alconox) followed by a tap water rinse, followed by a thorough spray with methanol and deionized water.

REFERENCES

Puget Sound Estuary Program. 1986a. Recommended Protocols and Guidelines for Measuring Selected Environmental Variables in Puget Sound. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

Puget Sound Estuary Program. 1986b. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound. U.S. Environmental Protection Agency, Region 10, Seattle, WA.

bcc: M. R. Foresman
W. D. Lambert

Monsanto

BRENT J. GILHOUSEN
Assistant General Counsel
Environmental

Monsanto Company
800 N. Lindbergh Boulevard
St. Louis, Missouri 63167
Phone: (314) 694-8504
Facsimile: (314) 694-2920

November 6, 1992

George S. Goodridge
Sr. Environmental Attorney
Legal Department
Rhone-Poulenc Inc.
CN 5266
Princeton, New Jersey 08543-5266

Re: Claim for Indemnification - Former Monsanto Vanillin
Production Facility, Seattle, Washington

Dear Mr. Goodridge:

This letter is a follow-up to our telephone conversation of October 26, 1992. My initial call to which you responded on October 26 was in response to Rhone-Poulenc's letter to Monsanto dated October 8, 1992 and received October 13, 1992. In that letter Rhone-Poulenc stated that it interpreted EPA's RCRA corrective action order as relating to indemnification obligations of the purchase and sales agreement of October 1, 1986 between Rhone-Poulenc and Monsanto Company.

In your letter you noted that specific time frames were set forth for notifying EPA. In our telephone call you said that Rhone-Poulenc would be notifying EPA of its intent to negotiate and to sign the order. On behalf of Monsanto I responded that if, after review of the Boeing Company's Landau Report, it felt it may be required to indemnify Rhone-Poulenc for government mandated cleanup it would want to exercise its rights pursuant to Article 12.4 of the Sales Agreement. I have not received from you a copy of the Landau Report. Could you please expedite its copying and express it to me.

Finally, EPA's letter transmitting the Order to Rhone-Poulenc set forth certain dates for reply by Rhone-Poulenc. You apprised me on the telephone that those dates were being modified. Please provide notice to Monsanto as of the status of those modifications.

Upon receipt and review of the Landau Report Monsanto will be in contact with you.

Sincerely,

